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Vol. 29. Index to Advertisers and Classified Index Following Reading Matter No. 15.

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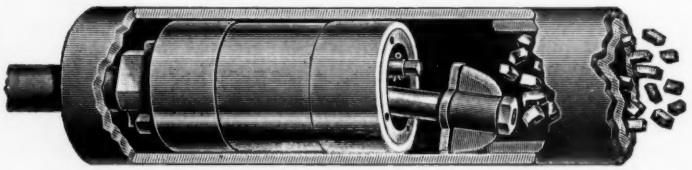

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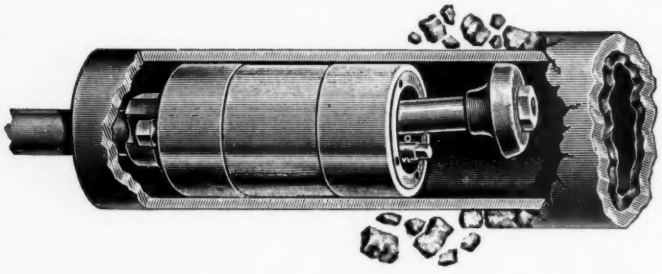

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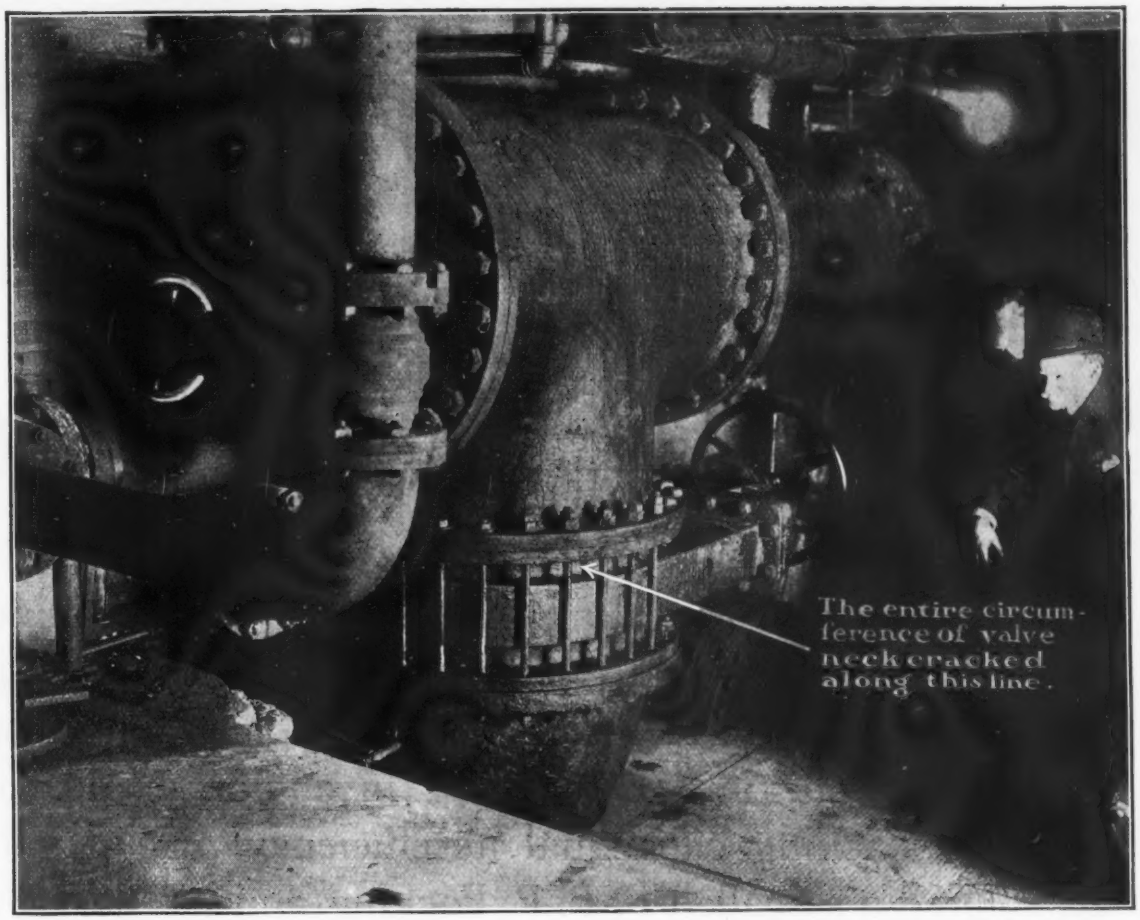

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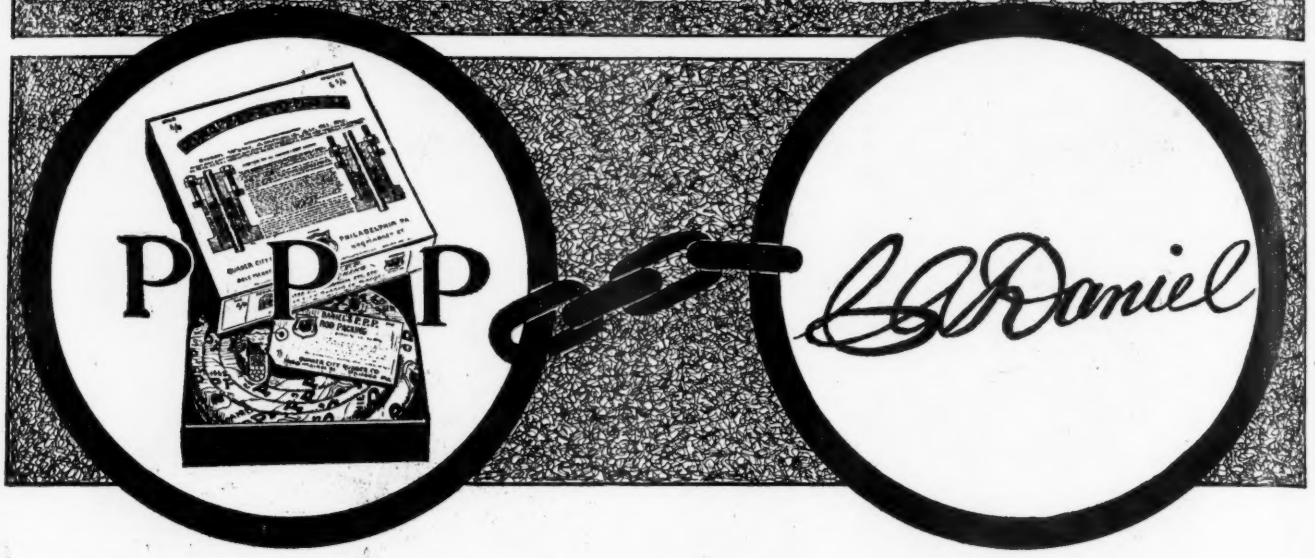

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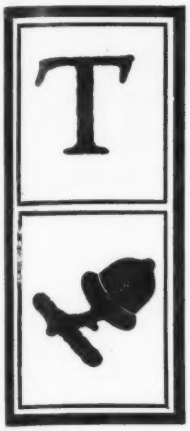

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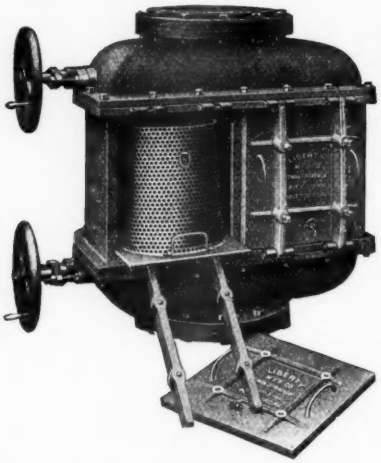
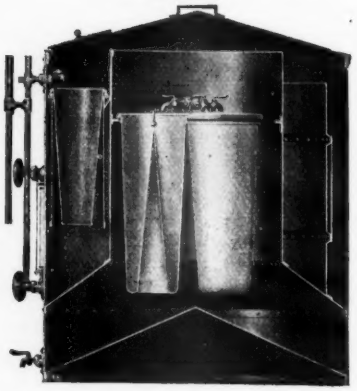


The Liberty Twin Strainer satisfies the need of a strainer that can be conveniently located and cleaned without affecting the water flow. As its name implies, it is *two strainers in* one—either basket being capable of being thrown out of service and cleaned while the other strains the water.

Tests prove that the Liberty Heavy Duty Turbine Cleaner thoroughly cleans a tube *in half the time* required to perform the same amount of work with the so-called "mechanical" or "power machine." One large manufacturer recently abandoned five power machines (costing $500 apiece) and now cleans boilers with the Liberty at a saving of 70%. The Liberty removes all the scale and leaves all the tubes.



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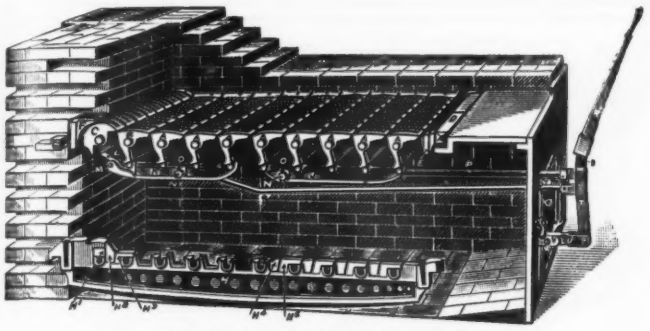

Plate No 1. Normal Position of Grate.

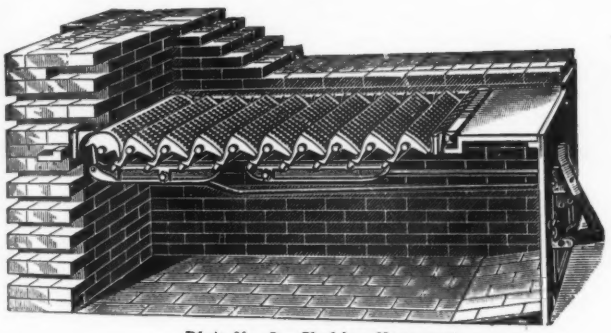

Plate No. 2. Shaking Movement.

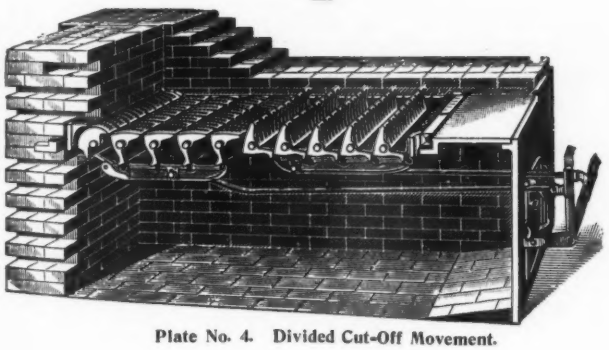

Plate No. 4. Divided Cut-Off Movement.

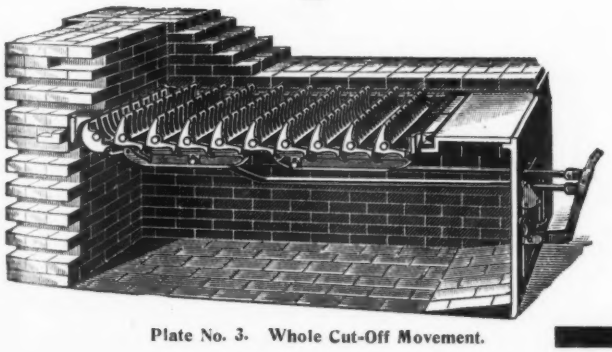

Plate No. 3. Whole Cut-Off Movement.

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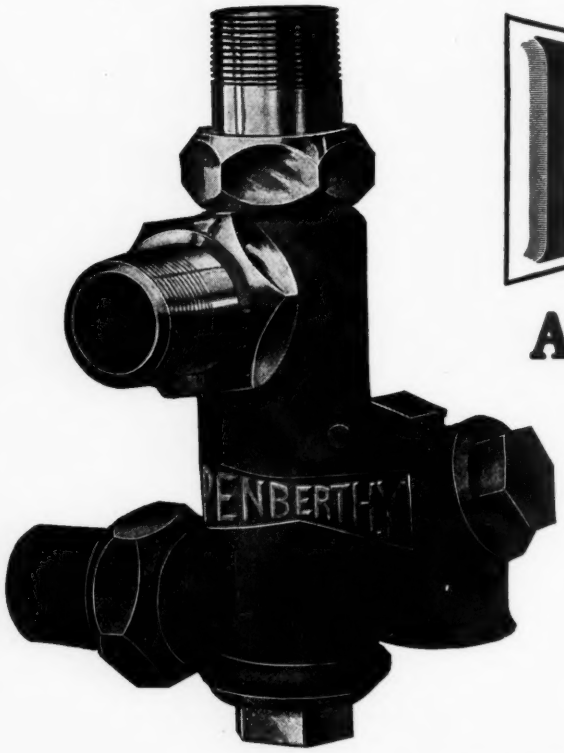

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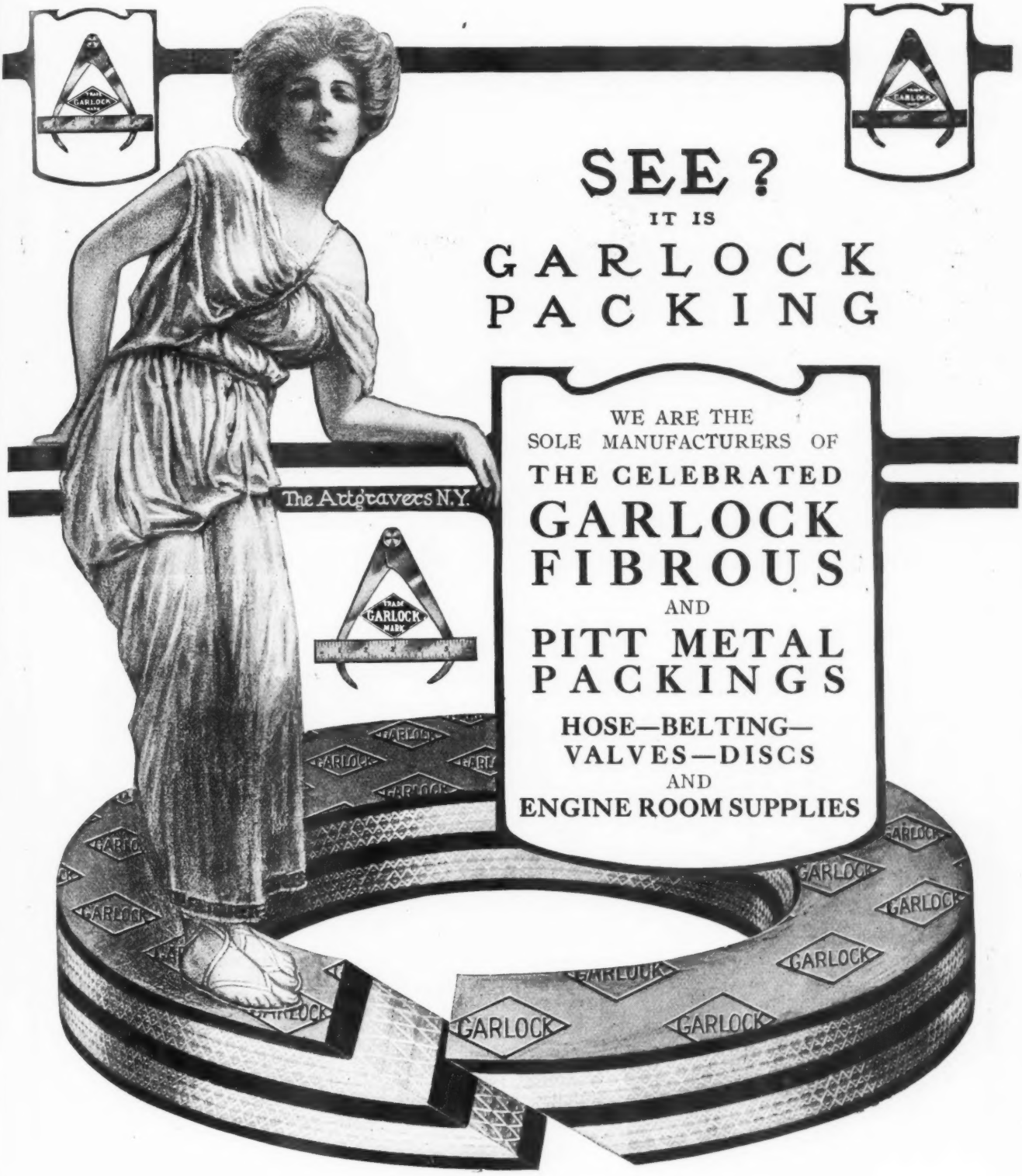

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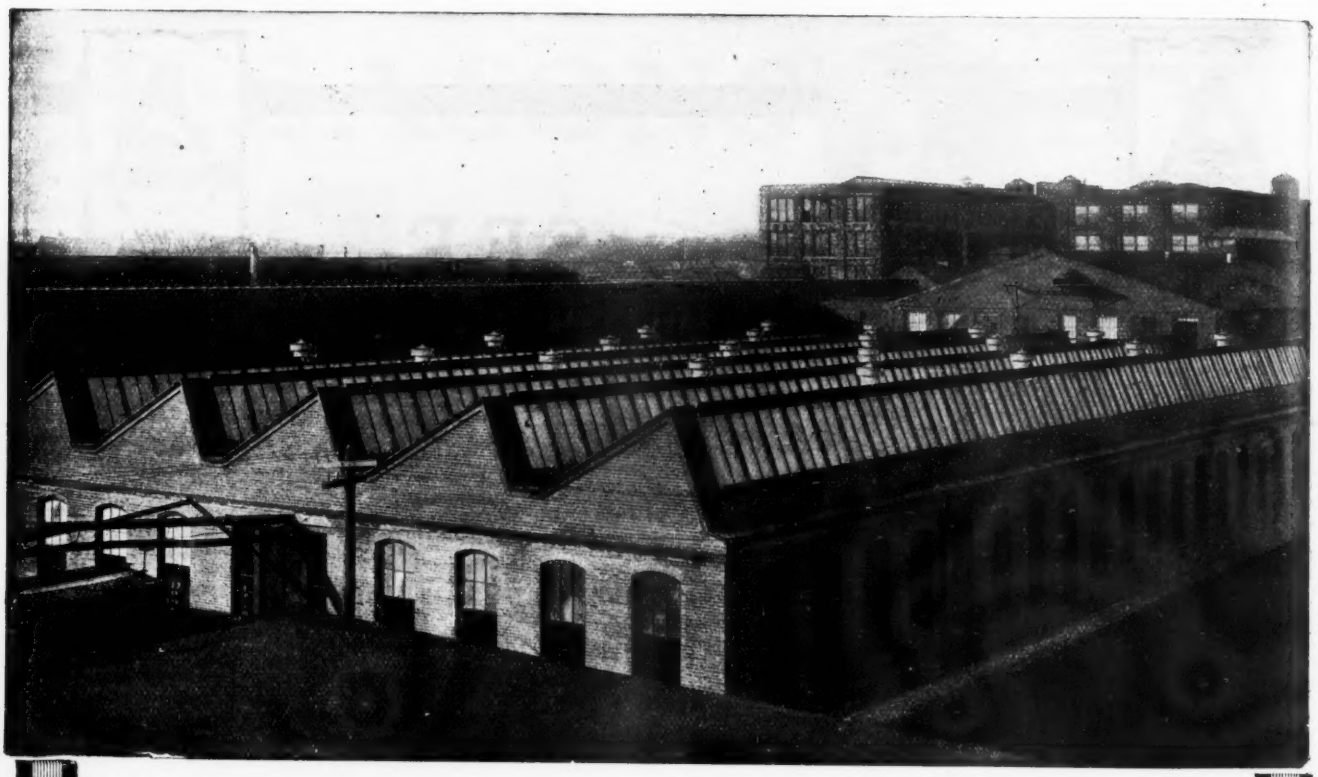

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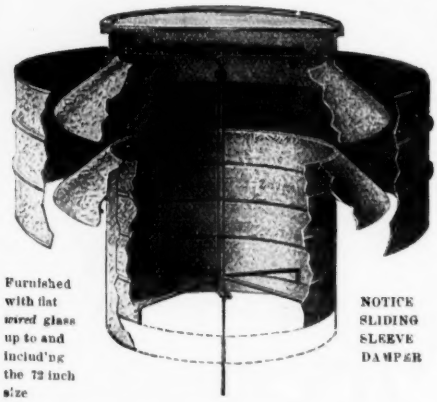

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A Mammoth Turbine for Buenos Aires

Of the Parsons Type, with Special Governing and Unusual Auxiliaries, Designed to Operate on 13.86 Pounds of Steam per Kilowatt-hour

BY FRANCO TOSI

The steam turbine illustrated herewith is of the Parsons type, with a low-pressure Fullagar compensator. All the plans were prepared in the offices of the Tosi firm, in whose shops the complete construction work was likewise done.

The turbine develops 12,000 horsepower under continuous operation and 14,200 horsepower for a term of two hours. It is designed to be operated on superheated steam at 572 degrees Fahrenheit and at a pressure of 162 pounds gage. The turbine is provided with a surface condenser, the turbine, including the condenser and alternator, is 827,000 pounds. Figs. 1, 2 and 3 show the complete set in plan and elevation, Fig. 4 a vertical section through the turbine, and the construction details of both the turbine and the condenser are illustrated in subsequent drawings.

The chief components of the turbine are the stationary part, known as the cylinder, bearing the distributing blades, and the movable part, known as the shaft, on which are mounted the individual wheels acted upon by the steam directed against of steam admitted to the turbine. The turbine shaft is mounted on two spherical bearings provided with pressure lubrication. It is connected with the alternator shaft by a joint which allows of a slight displacement, and the flange around the shaft at the two points where it projects from the cylinder is made steam-tight by means of grooves.

The turbine end of the high-pressure side is provided with an endless screw which transmits its motion by means of gearings to two vertical shafts making

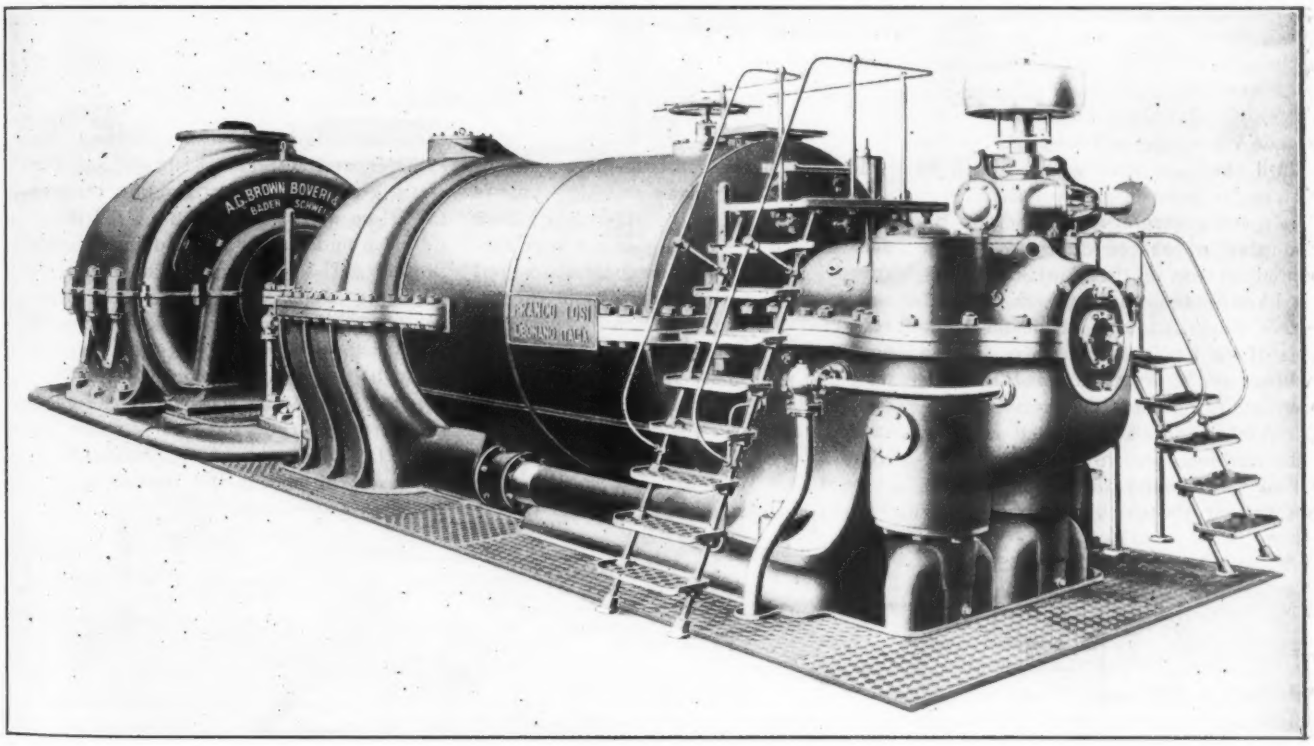


FIG. 1. ONE OF THE 12,000-HORSEPOWER TOSI TURBINES

and is the first of three turbines which the Tosi firm has under construction for a steam-power plant at Buenos Aires. Its speed rotation is 750 revolutions per minute, and it is directly coupled to an alternator constructed by the firm of Brown, Boveri & Co., Baden, designed to furnish a three-phase current of 12,000 volts, frequency 25 and power factor 80. The generator is provided with a 220-volt exciter, the latter likewise directly coupled. The steam consumption will be 13.86 pounds per kilowatt-hour. The total weight of them from the distributing blades. The cylinder, which is made of a special grade of cast iron and was cast in the Tosi shops, has a total weight of 110,230 pounds. It is divided along a horizontal plane into two parts, each of these parts consisting in turn of two other parts, the heavier of which weighs 42,300 pounds.

A valve chest, placed alongside the cylinder, contains the main steam valve, which is operated by hand, and the admission and throttle valve, operated by an auxiliary motor for regulating the amount 175 revolutions per minute, on each of which is mounted a rotary pump drawing oil by suction from the storage base supporting one end of the cylinder, and thereupon compressing the oil to 1½ atmospheres. The two pumps operate in parallel and discharge their oil into one and the same pressure tube, through which it is fed to the bearings, after passing through an oil cooler. A small auxiliary steam pump is provided for feeding the lubricant to the bearings when the turbine is started, inasmuch as

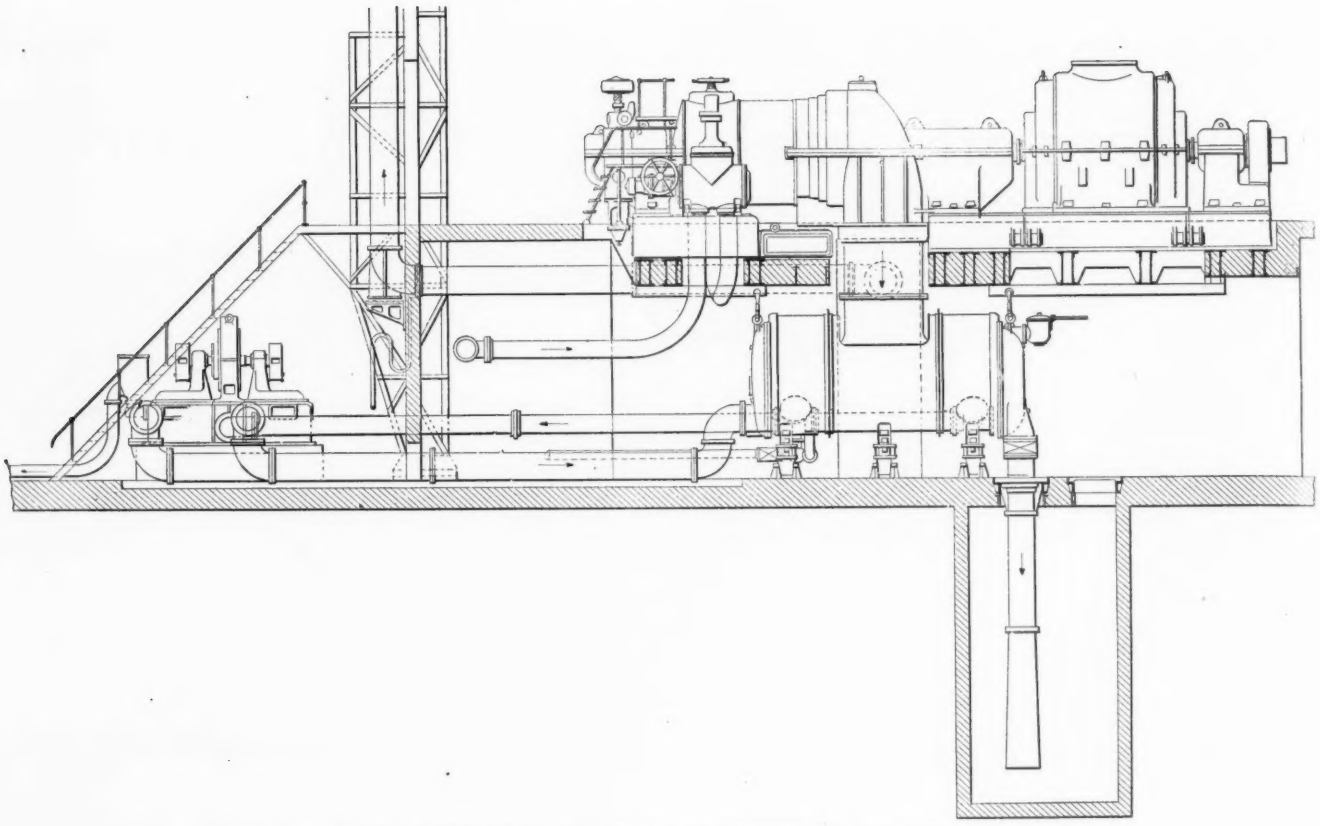


FIG. 2. ELEVATION OF TURBINE AND CONDENSING EQUIPMENT

the main oil pumps will not suck up the oil until they are making one-fourth of their regular number of revolutions.

The speed governor, which operates the slide valve of the auxiliary motor, is mounted on one of these vertical shafts, as is likewise the safety governor which operates instantly on the hand-throttling device of the turbine steam valve closing it whenever the speed attained becomes more than 15 per cent. in excess of normal. A thrust bearing, located in front of the turbine, prevents axial displacement of the cylinder shaft and takes up the slight thrusts to which it is liable.

Cylinder and Blades

The cylinder is constructed so as to be as nearly cylindrical as possible. Cast-in steam channels have therefore been avoided, and pipes with packing were substituted in order to prevent all distortions and at the same time leave room for unrestricted expansion. Before the final boring, the cylinder was annealed at high temperature in a special furnace, and during this operation the deformities due to casting tensions, which would have become apparent later on, were at once developed.

The main valve chest, which has already been described, is separate from the cylinder, and rests on the baseplate. The steam going into the valve chest through the steam main passes through the throttle valve and is conducted to the cylinder through a U-shaped pipe capable of freely adjusting itself to expansion. The number of rotor elements is ample to allow of slight increases in the pressure exerted through them, and consequently limit the speed of the steam, so that its energy is transferred to the rotary parts under the most favorable conditions, inasmuch as the losses by shocks and friction are reduced to a minimum.

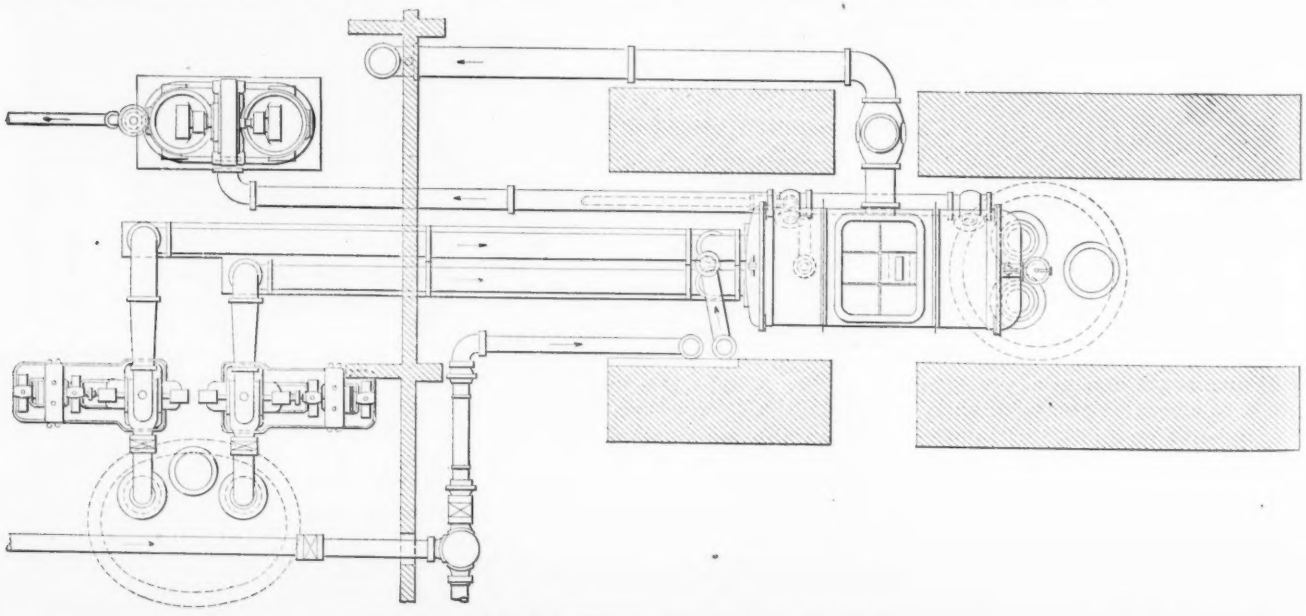


FIG. 3. PLAN OF CONDENSER, AUXILIARIES AND PIPING

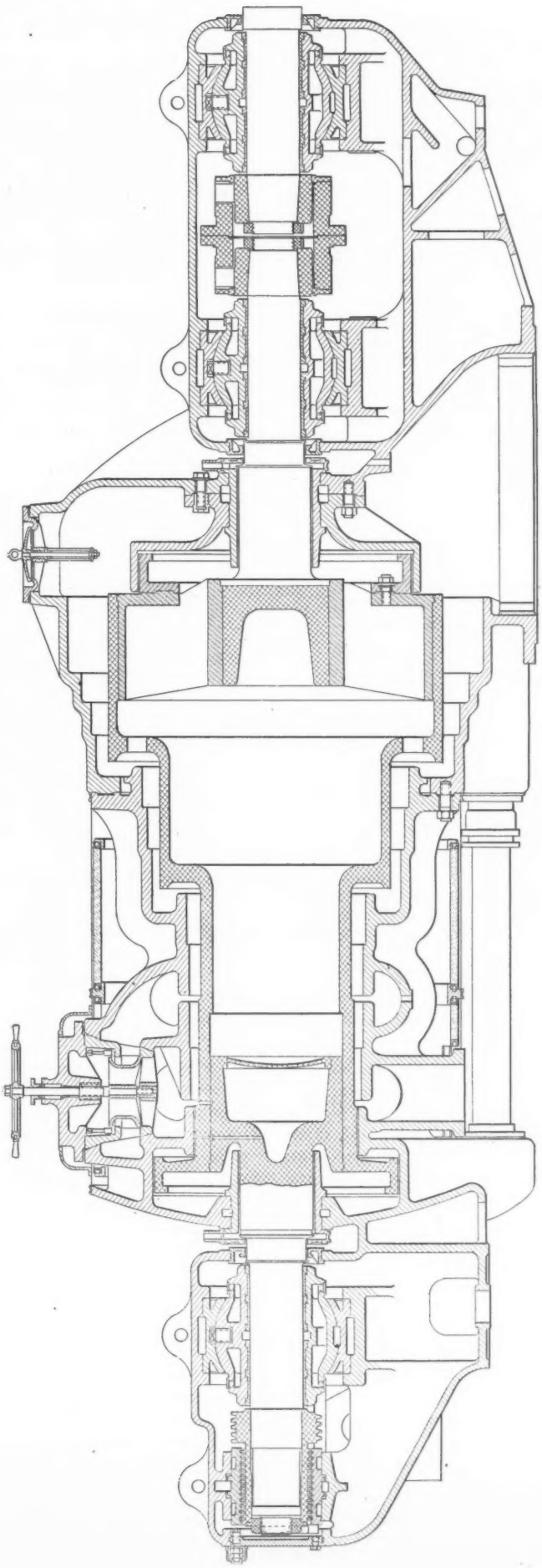


FIG. 4. SECTION THROUGH TURBINE AND BEARINGS

At the end of the blades the minimum radial clearance measures 0.072 inch, and is, therefore, small in comparison with the length of the blades. The loss by escape of steam at the periphery of the elements comprising the rotor consequently amounts to only a small percentage, and this loss does not have an altogether injurious effect on the efficiency of the turbine, because the steam, while escaping through the peripheral clearance, is strongly throttled. Thus, the loss in velocity is transformed into heat, and the steam consequently becomes superheated, or at least dryer, before acting on the next element, thereby reducing the frictional loss. If the large number of elements composing the rotor is taken into consideration, it is evident that the loss through radial clearance is reduced to a negligible quantity in view of the decrease in resistance due to friction.

The turbine-exhaust opening is rectangular in shape, its dimensions being restricted in the direction of the axis for the purpose of reducing the length of the cylinder as much as possible. The width of the opening, however, is ample, so as to adapt it, as it were, to the diameter of the condenser, in order to allow the steam to enter the condensing chamber without a streaming or revolving motion and thus to distribute itself uniformly over the entire surface of the tubes by which it is condensed.

Shaft

The shaft drum was made from one piece of forged steel. It was delivered roughly finished by the Cockerill shops, at Seraing, and was annealed in the same way as the cylinder before the final finishing work was completed. On the low-pressure side, the drum is joined by cast-steel cross pieces to the cast-steel journal, the parts being driven one into the other while hot. On the high-pressure side, the journal was merely driven into the drum while hot, and a steam-circulating chamber is provided for the purpose of making the expansion of each part counterbalance that of the other, thereby securing a rigid joint. The constructing firm adopted a flange joint for other turbines, secured by screws, but adhered to the use of the steam-circulating chamber in the present instance. The total weight of the shaft, including the blades, is 52,470 pounds.

Distribution

The auxiliary motor which operates the admission valve is not itself operated by steam, as in the Parsons type of turbine, but by oil under a pressure of 1½ atmospheres, the same being supplied by the pumps. The use of steam requires the most careful maintenance of the various parts, more especially in plants where the steam is not sufficiently pure, as a result of impurity in the boiler feed water. The use of oil obviates this difficulty, inas-

much as all the parts are kept at low temperature and thoroughly lubricated. The turbine cannot be started if the engineer forgets to start the small auxiliary oil pump, and this will prevent possible damage to the bearings from which all the oil is thoroughly wiped off before the turbine is started. The turbine will stop whenever the supply of oil under pressure supplied by the pump is, for one reason or another, interrupted.

Although the steam pressure has little influence on the number of revolutions made by the turbine, it has a very considerable influence on the steam distribution. This is highly important, because the pressure in the boilers varies continually and is reduced (especially when the firemen are not prepared for it) whenever the load is at its maximum, thereby tending to cause a considerable reduction in the number of revolutions made by the turbine.

The distributing mechanism is composed of the following parts: The rod of the balanced admission valve *A*, Fig. 6, which has a double seat, is connected by means of a joint which leaves it free to revolve to the rod of a piston *B* which slides in cylinder *C*, in the lower part of which the oil under pressure is admitted and discharged by a rotary slide valve *D*. This slide valve is operated by the centrifugal governor *R*, Fig. 7, by means of the levers *E*, *F*, *G*, *H* and of the rod *I*. A spring *L*, Fig. 6, balances the pressure of the oil under the piston.

The slide valve *D*, Fig. 6, is provided with four longitudinal channels through which the oil under pressure passes into the cylinder *C* whenever the piston *B* is to make its upward stroke, while the oil in the cylinder *C* is discharged through the said channels whenever the piston *B* is to make its downward stroke. The rotary sliding valve *M*, which revolves around the sliding valve *D* and is operated by the rod of the piston *B* by means of the levers *P* and *Q*, is provided with holes which correspond with the channels of *D*. Both sliding valves *D* and *M* revolve in a chamber *N*, connected with a tube feeding oil under pressure, and with a discharge tube.

Under ordinary conditions of operation, the slide valves *D* and *M* are in a position closing the admission and discharge channels. Whenever the load increases, the centrifugal governor descends and causes *D* to revolve so as to open the channels for the oil under pressure. The piston *B*, starting on its upward stroke, opens the valve *A* and causes the sliding valve *M* to revolve, so as to close the open channels of slide valve *D*. The valve thus stops in the position adapted to the new load, and, the adjustment having been accomplished, the two sliding valves *D* and *M* now occupy the same position in relation to each other as they previously did. In other words, they are in a position in which they may be said to form one single rigid pivot, while the operation is the same as if the governor, in causing this point to revolve, had brought the valve directly into its new position.

This adjustment is quickly accomplished, because the slide valve *D* opens up a large admission and discharge space for the oil, so as to make the piston *B* and the valve *A* ascend and descend rapidly. The adjustment is reliable, because the valve, in carrying along the valve *M*, rapidly closes the opening which had been just previously opened, and thus prevents any over-adjustment. The adjusting device is also sensitive, because the slide valve *D* is perfectly balanced by the peculiar arrangement of its channels, and it is powerful in view of the ample dimensions of the oil piston *B*, these being sufficiently large to provide considerable power for overcoming any frictional resistance which might develop in the auxiliary motor. All the parts of the steam-distributing apparatus are kept continuously in a slight oscillating motion, so as to minimize friction, this result being obtained by means of the lever *G*, the pivot of which is so forged as to be eccentric.

Insulation

The cylinder is provided with an insulating layer placed under its outer covering of bright sheet metal, so constructed as to allow of its being removed and put back into place without injury. This arrangement reduces the external heat losses, while insuring a more uniform temperature of the inside and outside parts of the cylinder walls, and keeps the outside temperature of the engine at a low point.

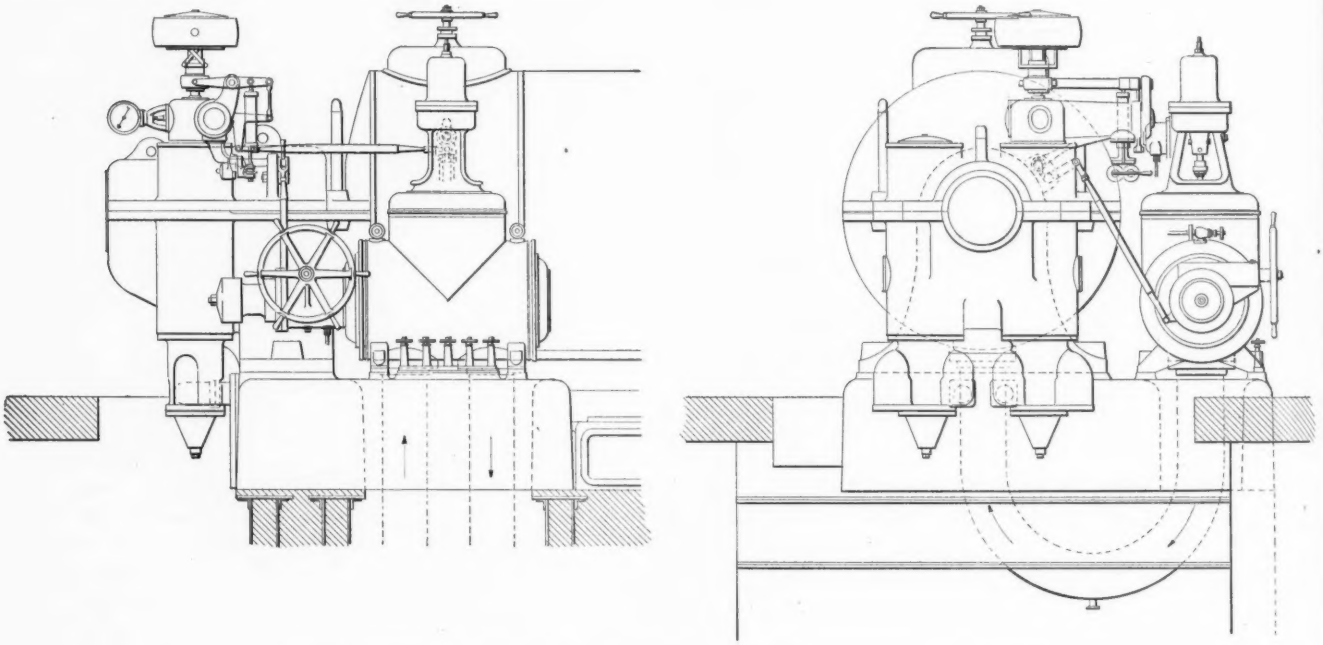


FIG. 5. FRONT AND END VIEWS OF TURBINE, SHOWING GOVERNING MECHANISM

Axial Thrust

The thrust of the shaft was measured during the testing of the turbine by the oil-pressure device shown in Fig. 11. This device consists of a disk *S*, revolving in a chamber *T*, into which the oil under pressure provided by the pumps is fed through a small tube. The disk is fastened by a grooved flange to the collar *U*, which is in turn fastened to the cover of the device in such a position as to leave the grooves a clearance of 0.002 inch. The proportions of the shaft are such as to have it exert a constant thrust in the direction of the arrow *X*. By the action of the oil pressure the shaft is thrust in the

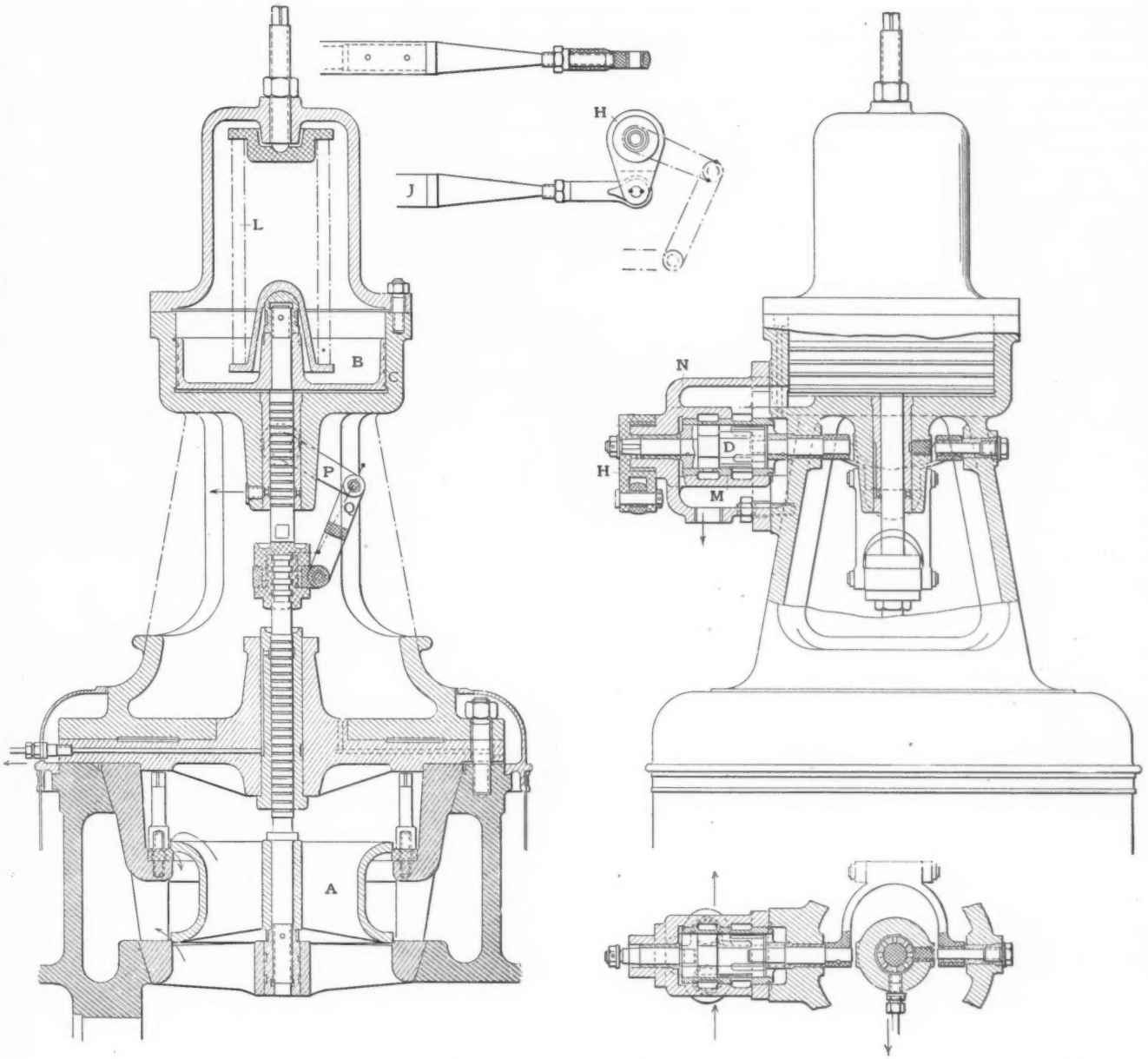


FIG. 6. ADMISSION-VALVE MECHANISM

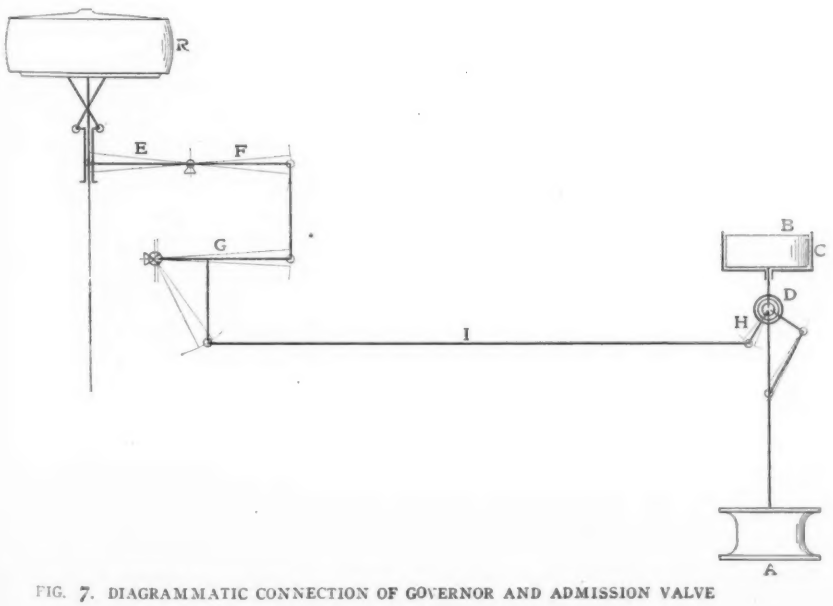


FIG. 7. DIAGRAMMATIC CONNECTION OF GOVERNOR AND ADMISSION VALVE

direction of the arrow *Y*, but, as soon as this motion commences, the pressure is reduced by the increased leakage through the grooves, and the shaft returns in the direction of the arrow *X*, this axial motion being constantly repeated. The pressure under which the shaft began to move was found to be 4.41 pounds, and the thrust of the shaft equal to 141 pounds. The pressure exerted by the shaft on its ample thrust bearing is consequently a negligible quantity.

The Condenser

The condenser is of the surface type, and thus permits the use of all the condensed steam, which is absolutely pure and free from oil, for feeding the boilers. All that has to be added to the feed water is the volume represented by losses through the boiler fittings, the pipes, etc., which amounts only to a small percentage. The illustrations show the

arrangement of the installation, which consists of the condensing chamber, located immediately under the turbine, a wet-packed air pump which extracts the gaseous products and the condensed steam from this chamber, and the two centrifugal pumps supplying the circulation water. The turbines are to be installed in a long room, measuring 92 feet in width and stated to be 29 feet in hight; the condenser pumps are in an adjacent room, the hight of which is 11 feet. The former is provided with a 30-ton, and the latter with a 10-ton traveling crane. All the devices belonging to the condenser-pump motors are located in a gallery, measuring 29 feet, which runs along the length of the pump room and from which the operation of the pumps may be watched.

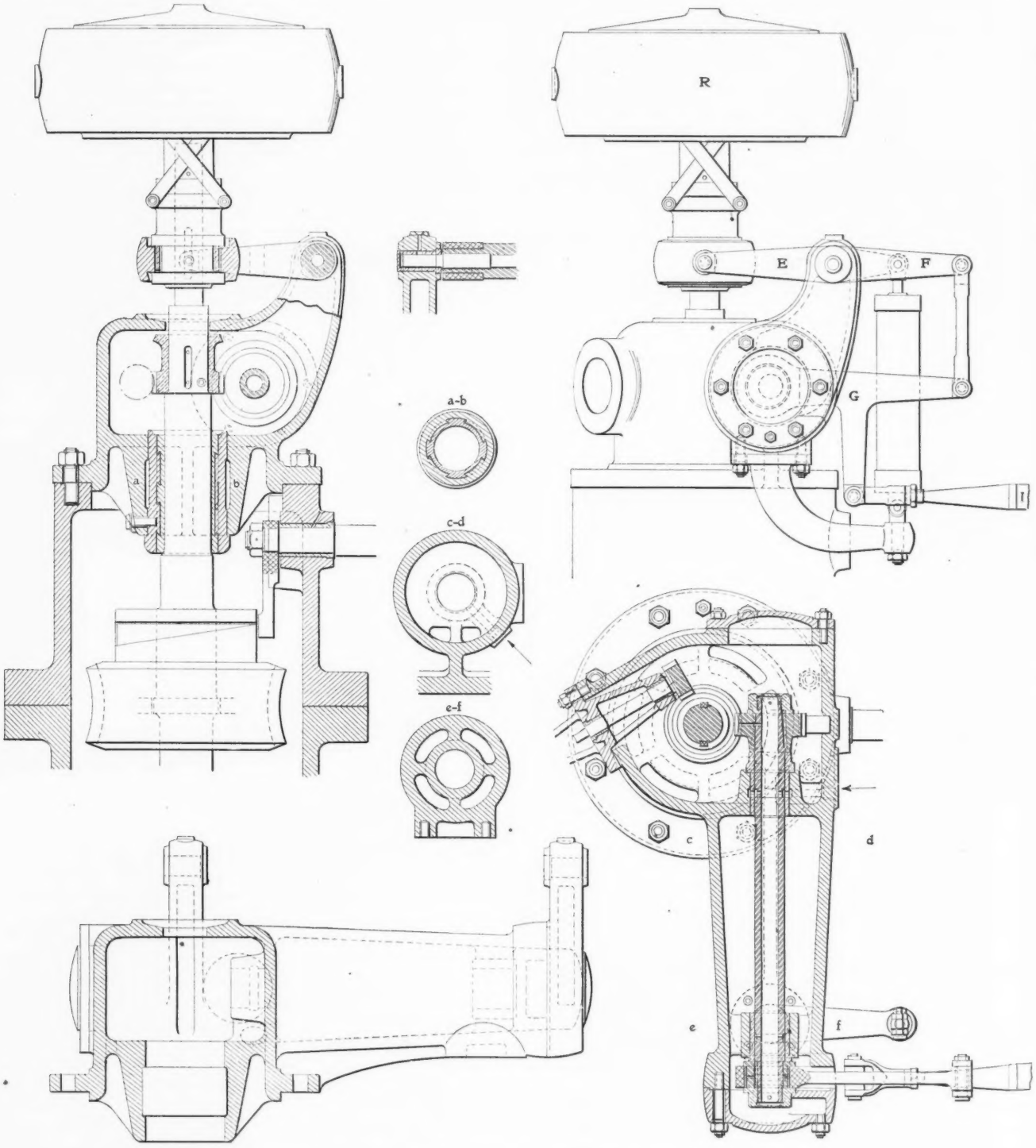


FIG. 8. DETAILS OF CENTRIFUGAL GOVERNOR AND SLIDE-VALVE MECHANISM

The condensing chamber has a cylindrical iron body, with a diameter of 100 inches, riveted by means of hydraulic power. The steam enters this cylinder through a rectangular opening at the top, subdivided into two currents, each of which makes three turns between the small brass tubes through which the condensing water flows, in order that the heat may be transmitted on the counter-current principle. The total condenser surface measures 14,000 square feet, provided by 3770 brass tubes of a special alloy, tinned both inside and outside, with an inside diameter of ¾ inch, an outside diameter of ⅞ inch and measuring approximately 10 feet in length. In view of this comparatively greater length, the tubes are not only supported at both ends

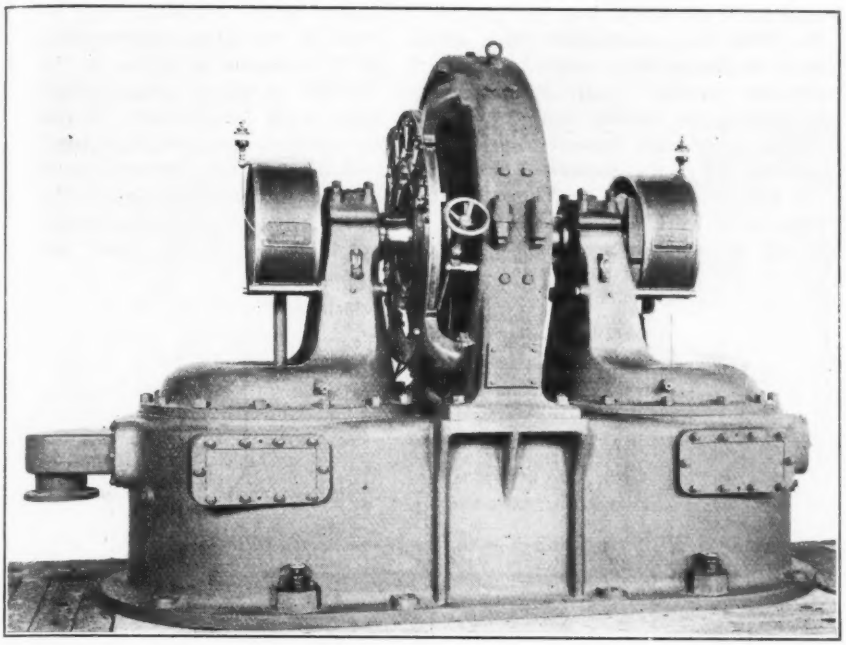


FIG. 9. MOTOR-DRIVEN AIR PUMP

by the Muntz yellow-metal tube plates, but likewise by a third plate located midway. The places where the tubes pass through the tube plates are made tight by special packing devices which prevent longitudinal displacement of the tubes, and at the same time leave them free to expand. The steam-admission opening measures 64x80 inches, and under normal conditions 14,830 cubic feet of steam per second will pass through.

The condensing chamber does not rest rigidly on the floor, but is supported by three balancing devices, capable of balancing not only its own weight, but likewise that of a part of the tubing and of the condensing water. This arrangement is designed to relieve the turbine cylinder from the considerable strain resulting from the atmospheric pressure on the surface corresponding to that from which the pressure is removed, amounting to about 68,340 pounds, while at the same time leaving the various parts absolutely free to expand. This strain is, of course, always present, but its only effect is to compress the connecting flange between the turbine and condenser. If, on the other hand, an arrangement had been adopted (to allow of unrestricted expansion) consisting of a packed pipe or of an elastic joint between the turbine and the condenser, the effect of the atmospheric pressure would, on the one hand, relieve the weight of the condensing chamber, while on the other hand it would place a load on the turbine cylinder, causing the latter to get out of shape.

Air Pump

The air pump consists of two cylinders, with vertical axes operating in parallel, each of which is a two-period, double-

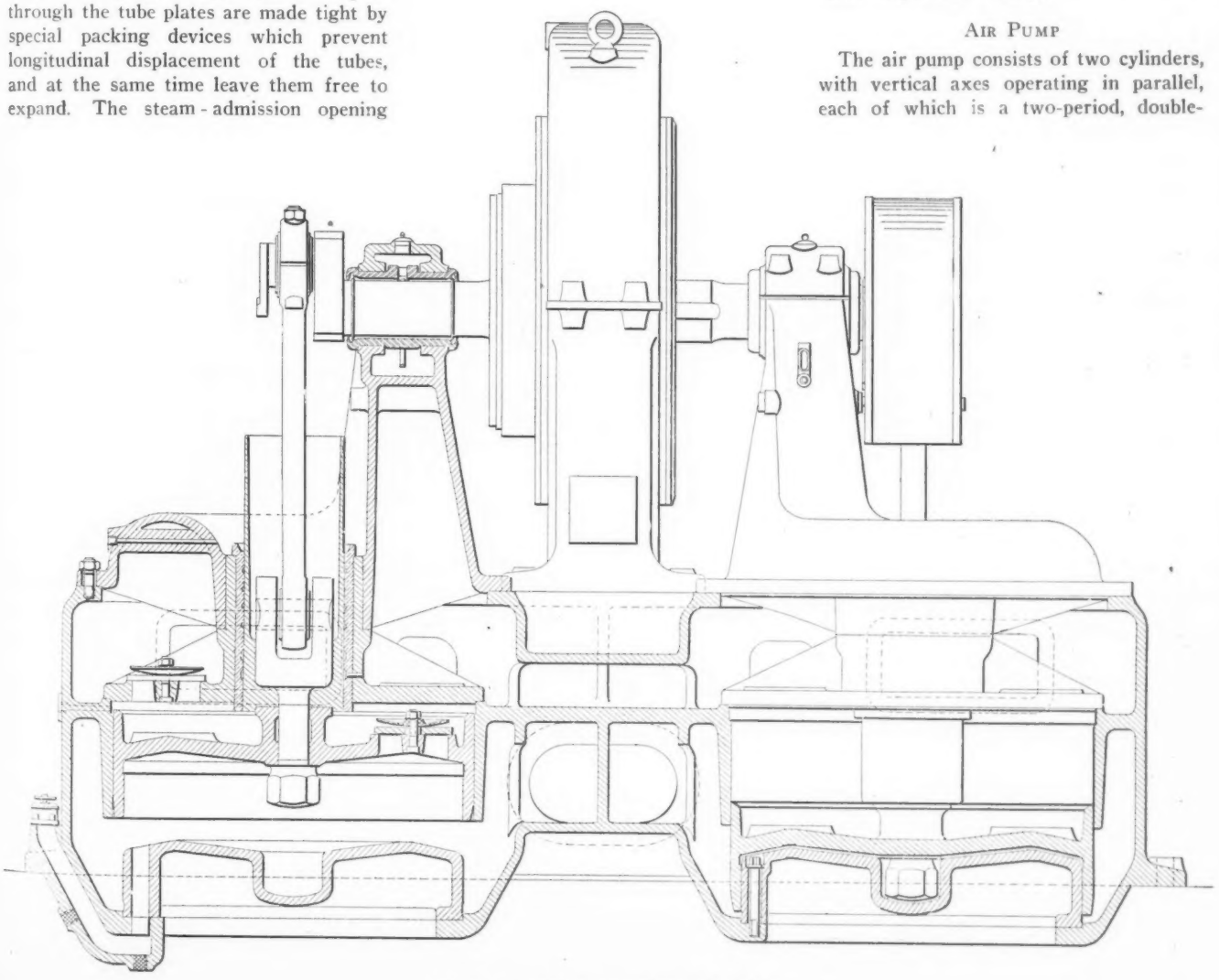


FIG. 10. SECTION THROUGH AIR PUMP

acting compressor, both periods being combined in one single cylinder with only one piston, provided with valves. The lower part of the piston receives the action for the first period and the upper part for the second period. Reference to Figs. 9 and 10 will show the construction of the pump.

In making its upward stroke, the piston exhausts the lower compartment, not through valves which would produce resistance, but through an annular aperture which opens automatically. On its downward stroke, the piston compresses the lower compartment and exhausts the upper chamber. On its second upward stroke it compresses the upper compartment and expels the air and water through the valve plate into the chamber under the piston. During the first period the compression is consequently almost *nil*.

As regards volume the waste space is small, and is under a slight pressure, about equal to that of the condenser. The volumetric output is consequently large. The condensed water itself provides a tight closure in the connections between the exhaust chambers and the corresponding pressure chambers, and likewise for the piston slides. The closure is thus efficient, and without employing packing or springs. The wear on the pistons is small, inasmuch as they are vertically placed.

This type of pump affords the same advantages as dry pumps with box slide valves and compensating channels, while on the other hand it is simpler in construction and operates at a low temperature. The double-compression arrangement possesses the advantage of making it possible to maintain one solid column of water in the circulation tubes, inasmuch as the resistances to be overcome by the centrifugal pumps are limited to those inside the tubes and to the difference between the level of the two channels. In order to maintain this unbroken column, it is necessary to extract the air which gathers at the highest point of the tubes, since it would otherwise accumulate and increase the resistance which the centrifugal pump would have to overcome. Instead of providing a special pump and an ejector for extracting the air in question, the second compression chamber of the air pump is used for this purpose, and practical experience has thoroughly demonstrated that this does not influence the vacuum which can be produced in the condenser.

The diameter of the pump piston is 44 inches at the lower end and 46.8 inches at the upper end, the total stroke being 11 inches. The rotor of the electric motor is mounted on the pump shaft, which latter is integral with two cranks. The motor is rated at 80 horsepower, and is a direct-current, 440-volt machine making 145 revolutions per minute. For ordinary operation, the power consumption will be only 60 horsepower, but the power of the motor was nevertheless made ample, so as to give a heavy torque at the start, although starting is already made easy by opening the starting valves.

The centrifugal pumps operate in parallel, and each is capable of circulating 112 gallons per second. They are constructed to work against a resistance of 33 feet in each, and are coupled to a 90-horsepower 400-volt direct-current motor, making 495 revolutions per minute. The 33 feet includes, in addition to the resistance of the condenser and pipes, a difference of 8.2 feet between the level of the suction channel and that of the discharge channel.

As previously described, the circulating pipes operate like a siphon. At their highest point a chamber has been provided in which the air accumulates. This air is extracted by means of the second chamber of the air pump, a small check valve being interpolated. In case no air accumulates, communication may be interrupted by a float-operated valve. This obviates the possible danger of the cooling water being extracted by suction. It is not fit to use as feed water and, if extracted, would become mixed with the condensed steam.

An attachment to the condenser, consisting of an automatic valve, allows the steam to escape freely from the turbine in case the condenser motors should stop, and closes automatically as soon as the motors are again running at normal speed.

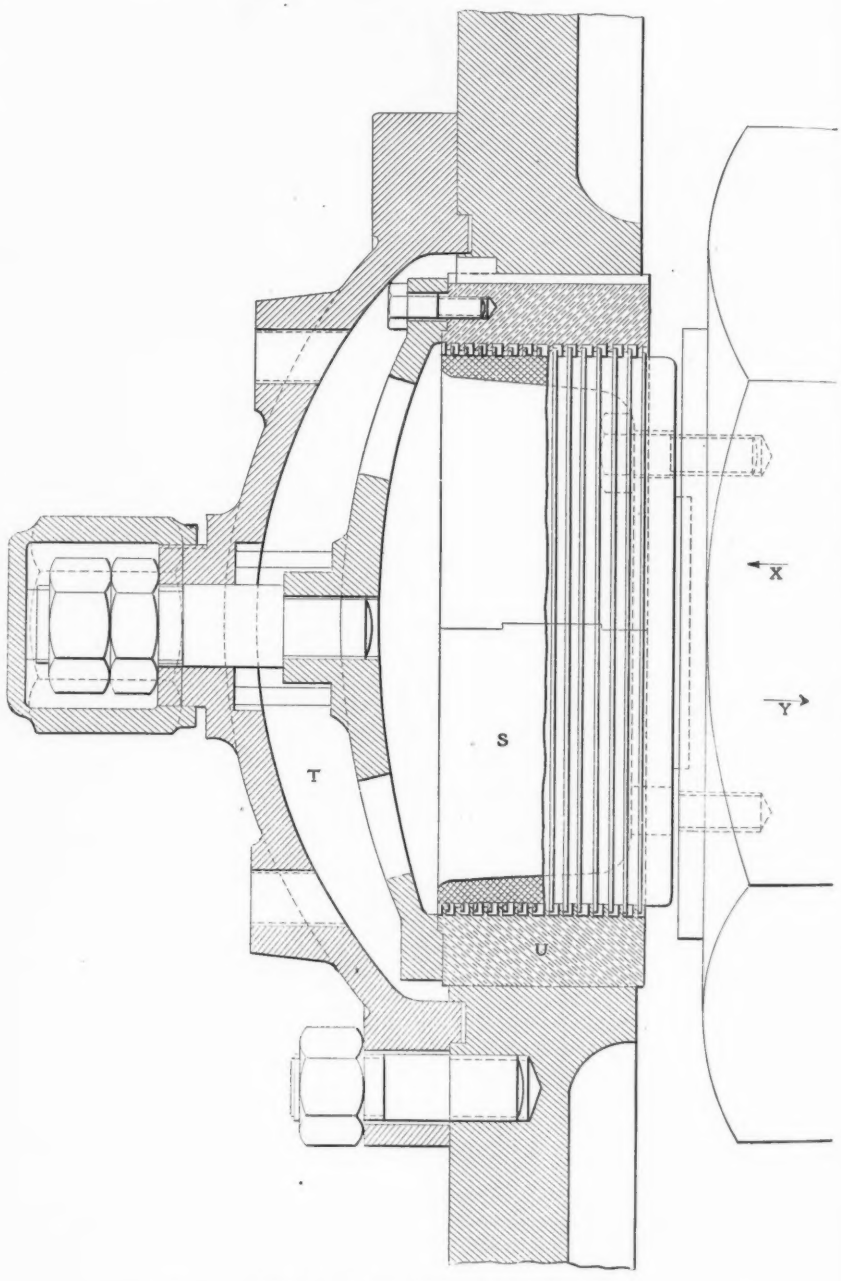


FIG. 11. DEVICE FOR MEASURING SHAFT THRUST

Influence of Valves on the Flow of Water

By Fred Pillmore

The effect on the amount of fluid which will flow through a pipe when that flow is throttled by a valve, is something upon which there seem to be but few data obtainable. Several years ago the writer had occasion to put in about a mile of 1¼-inch water pipe, with a head of about 90 feet, to supply some residences with spring water. The pipe was fed from a large cypress tank sunk into the ground and provided with an overflow, so that the tank was always full and gave an ample supply to fill the pipe at all times. The question was asked by one of the residents as to how much of a jet could be thrown from the discharge end of the pipe. To get an idea of this, a ¼-inch hole was drilled through a pipe cap, and the cap screwed onto the discharge end of the line. To our surprise it was found that as nearly as could be measured by catching the water in pails, the number of gallons per minute flowing from the ¼-inch orifice was the same as that flowing from the pipe when the end was fully open, though, of course, in the first instance the stream could be thrown quite a distance. The explanation seemed to be that the resistance offered by the small opening was so slight, as compared with the friction of the mile of pipe, as to be practically negligible.

FLOW OF WATER THROUGH PIPES.

Position of Valve at Discharge End of Pipe.	Head in Inches.	Flow in Lb. per Minute.			
		50 Ft. of ½" Pipe.	100 Ft. of ½" Pipe.	50 Ft. of 1¼" Pipe.	100 Ft. of 1¼" Pipe.
Valve full open....	3	8	2	32	22
Valve full open....	6	9	3½	49	33
Valve full open ...	12	12	8	66	47
Valve full open....	24	16	10	97	75
Valve ¾ open	3	8	2	32	19
Valve ¾ open.....	6	9	3½	48	32
Valve ¾ open.....	12	11	8	64½	46
Valve ¾ open	24	15	10	94	72
Valve ½ open	3	7	2	25	15
Valve ½ open.....	6	8	3½	42	29
Valve ½ open.....	12	10	8	54½	42
Valve ½ open.....	24	13½	10	82	70
Valve ¼ open.....	3	..	..	19	14
Valve ¼ open.....	6	..	..	23	20
Valve ¼ open.....	12	..	..	38	29
Valve ¼ open.....	24	..	6½	50	45

At another time a question arose as to the effect of valves on the flow in the pipe lines of a hot-water heating system, and some simple but instructive experiments were conducted to determine this, as follows:

A line of wrought-iron pipe was screwed together, and at one end was placed a valve; the other end was connected with the bottom of a pail. With this arrangement, and keeping a constant level of water in the pail, any desired head of water above the discharge end of the pipe could be maintained by raising or lowering the pail as occasion demanded, and the approximate opening of the valve gate could be gaged by the eye. The water used was at about atmospheric temperature, and tests were made with 50 feet of ½-inch pipe, 100 feet of ½-inch pipe, 50 feet of 1¼-inch pipe and 100 feet of 1¼-inch pipe, with the valve full open, three-quarters open, one-half open and one-quarter open in each case, except that with the ½-inch pipe haste made it necessary to leave out the one-quarter opening series.

The accompanying table shows the amount of water which flowed per minute

FIG. 1. FLOW OF WATER THROUGH 50 FEET OF ½-INCH PIPE

FIG. 2. FLOW OF WATER THROUGH 100 FEET OF ½-INCH PIPE

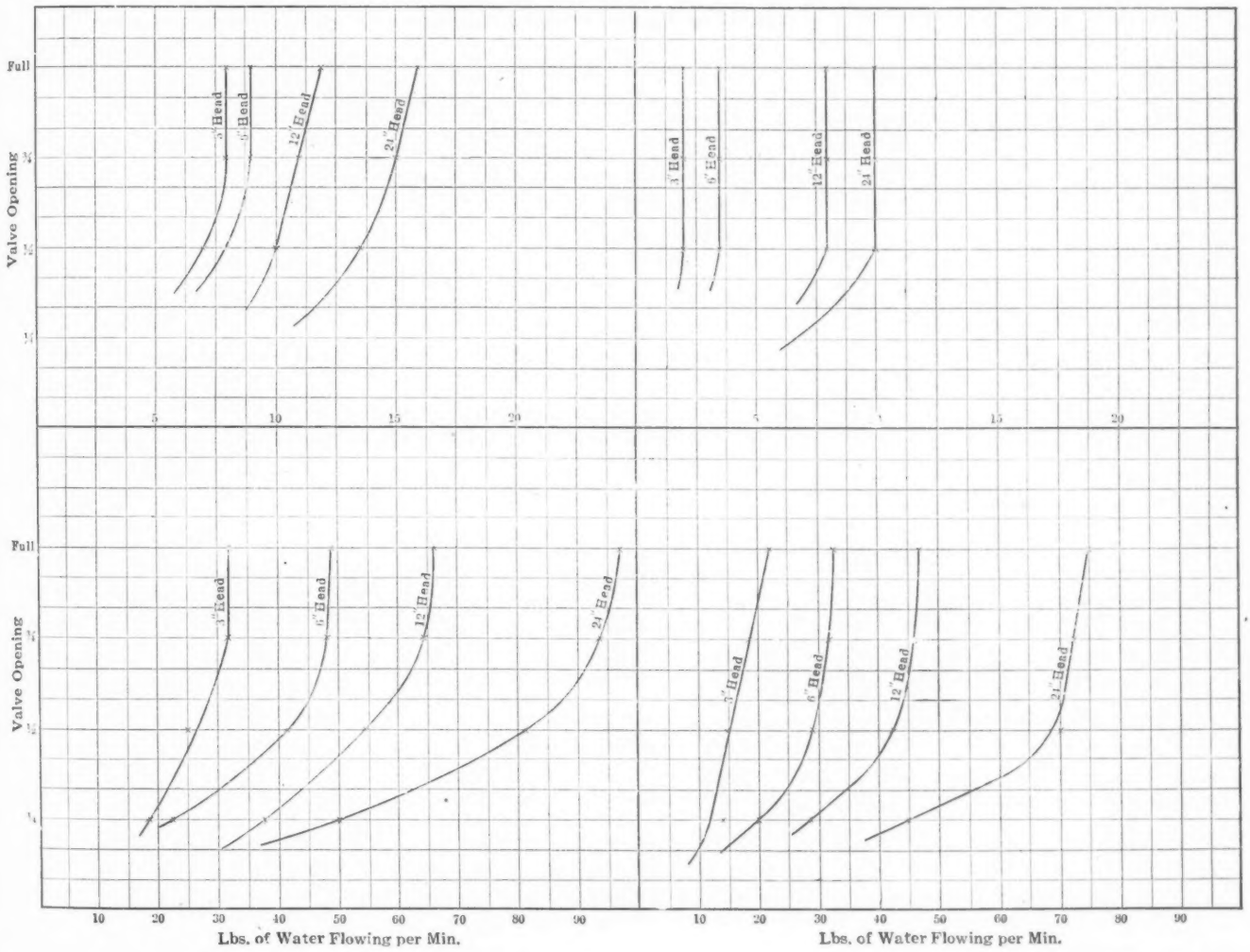


FIG. 3. FLOW OF WATER THROUGH 50 FEET OF 1¼-INCH PIPE

FIG. 4. FLOW OF WATER THROUGH 100 FEET OF 1¼-INCH PIPE

through the pipes in each case and in order to place the results in a form where the variations can be more readily discerned, the diagrams herewith have been plotted. A little study of these diagrams will indicate the following points:

First—That within a certain range the partial closing of a valve will have little or no effect upon the flow, even to closing it half off. This is clearly shown in Fig. 2, and it is also shown that if any material length of pipe leads to a hot-water radiator, the control, by closing a valve, is only obtained during the latter part of the closing, unless the valve be smaller than the pipe.

Second—That the same amount of closing has more effect on short pipes than on long ones.

Third—That the percentage of restriction offered by the valve does not vary materially with the head or pressure, at least through the low ranges usually encountered in heating work.

Increasing the Power of an Engine

By A. J. Dixon

A question that now and then confronts the applicant for an engineer's license, and one which also quite frequently suggests itself to the thinking engineer when dealing with governor problems, is this: "Can the power of a Corliss engine be increased by changing the weight of the governor counterpoise?"

This question, of course, presupposes a Corliss engine equipped with the type of pendulum governor, designed and introduced with steam-engine practice by Charles T. Porter, in which the influence of gravity on the governor mechanism is enhanced by means of a central counterpoise weight sliding freely upon the governor spindle, without at the same time affecting the centrifugal forces set up in the balls and arms at any given speed. The problem involved, therefore, appears on the face of it to be a very simple proposition, and for the purely abstract case proposed, the question might readily be answered in the affirmative; for, it would seem that adding weight to the counterpoise would cause the governor balls to revolve in a lower plane for the same speed, thus giving a later point of cutoff and hence a greater mean effective pressure and more power; or otherwise it would require a higher velocity to maintain the balls in the same approximate plane of flotation, thus preserving very nearly the same point of cutoff and mean effective pressure as before, but necessitating a higher piston speed and thereby attaining greater power.

To ascertain how this would work out in actual practice, let it be assumed that a certain Corliss engine is developing 800 horsepower while running at a speed of 100 revolutions per minute and cutting off at 9/16 of the stroke, and it is desired to increase the power of this engine to 880 horsepower by altering the governor counterpoise.

With the mean effective pressure due to cutoff at 9/16 of the stroke, the engine is developing

$$\frac{800}{100} = 8$$

horsepower per revolution. Therefore, if we can maintain the same initial pressure, and can closely approximate to the present point of cutoff under the modified condition, we can obtain the additional horsepower by running the engine at a speed of

$$\frac{880}{8} = 110$$

revolutions per minute.

Let it be further assumed that the diameter of the portion of the main shaft over which the governor belt runs is $13\frac{13}{16}$ inches, and that the diameter of the governor pulley is $11\frac{1}{2}$ inches. With these values and a crank-shaft velocity of 100 revolutions per minute, the speed of the governor spindle is

$$\frac{13\frac{13}{16} \times 100}{11\frac{1}{2}} = 120.1$$

revolutions per minute, or, say, 120 revolutions, allowing for slippage of the belt. With the increased crank-shaft velocity of 110 revolutions, the velocity of the governor spindle will be

$$\frac{13\frac{13}{16} \times 110}{11\frac{1}{2}} = 132.12$$

revolutions per minute, or, say, 132 revolutions.

Now, with respect to the principle of operation of the revolving pendulum or flyball governor, we know that the plane in which the revolving balls must be poised in order to operate the releasing gear for a particular point of cutoff depends for adjustment upon the relation of two opposing influences; these are, centrifugal force, which tends to rotate the balls and arms about their point of suspension in a direction upward and outward from the axis of the governor spindle, and gravity, which tends to rotate the balls and arms about the same point in a direction downward and toward the axis of the spindle. It is clear that these contending forces must balance each other when the balls are revolving in any plane of flotation; that is to say, the sum of the upward moments of the centrifugal forces of the balls and arms about their point of suspension must equal the sum of the downward moments of the weights of the balls, arms, and counterpoise about the same point.

This condition of balance or equilibrium is presumed to exist in the case of the aforementioned Corliss-engine governor, running at a speed of 120 revolutions per minute, when the balls are revolving in the plane required by the releasing mechanism in tripping the valves for cutoff at 9/16 of the stroke.

Let it be taken for granted that the vertical distance from this plane of equilibrium to the point at which the governor arms are suspended from the spindle, or as it is technically termed, the hight of the governor, is $11\frac{1}{2}$ inches, as shown in the accompanying illustration by the distance $B\,H$. Then, supposing the weight of each ball to be 20 pounds; the weight of each upper arm, concentrated at its center of gravity A, to be 5 pounds; the weight of each lower arm, concentrated at its center of gravity L, to be $2\frac{1}{2}$ pounds; and that the dimensions $A\,H$, $L\,H_2$, $B\,R$, $L\,R$, $W\,R_1$ and $A\,R_2$ are as shown in the figure. The dead weight acting along the axis of the spindle, necessary to bring about the aforesaid condition of equilibrium, must be 106 pounds.

This dead weight includes, beside the counterpoise, the weight of all the parts suspended from the collar to which the lower arms are connected. Assuming the combined effective weight of these parts, including the collar itself, the sleeve about which it revolves, the link rods and dashpot plunger, to be 6 pounds, the actual weight of the counterpoise is $106 - 6 = 100$ pounds.

Now, the proposition is to provide for a governor speed of 132 revolutions per minute while still maintaining a hight approximating closely to the original hight of $11\frac{1}{2}$ inches. It is quite apparent that if a plan were devised for running the governor at this increased speed without making any change in the weights, the centrifugal forces in the balls and arms would intensify to a considerable degree while the force of gravity would remain constant; so the natural consequence would be that the balls would fly outward, thereby diminishing their hight but increasing their radius from the axis of rotation, until the sum of the upward moments would again equal the sum of the downward moments, and a new plane of equilibrium would be established.

To prevent this condition, and to keep the balls revolving in the same plane of flotation as before, it would be necessary to counteract the enhanced centrifugal force of the balls and arms by gravitation, and the only way to accomplish this without further affecting the centrifugal forces at work, would be to increase the dead weight acting through the axis of rotation. In order to ascertain the amount of this increase, we must first calculate the centrifugal moments of the balls and arms under the modified condition of speed, and likewise the weight moments of the balls and arms.

Therefore, we apply the conventional formula for finding the centrifugal force of a revolving body, namely,

$$0.00034\ W\ r\ N^2,$$

where

W = Weight of the revolving body in pounds,

r = Radius of the circle in which the body revolves, in feet, and

N = Number of revolutions per minute.

We obtain for the centrifugal force of each ball

$$\frac{0.00034 \times 20 \times 11\ 5 \times 132^2}{12} =$$

113.546 *pounds*;

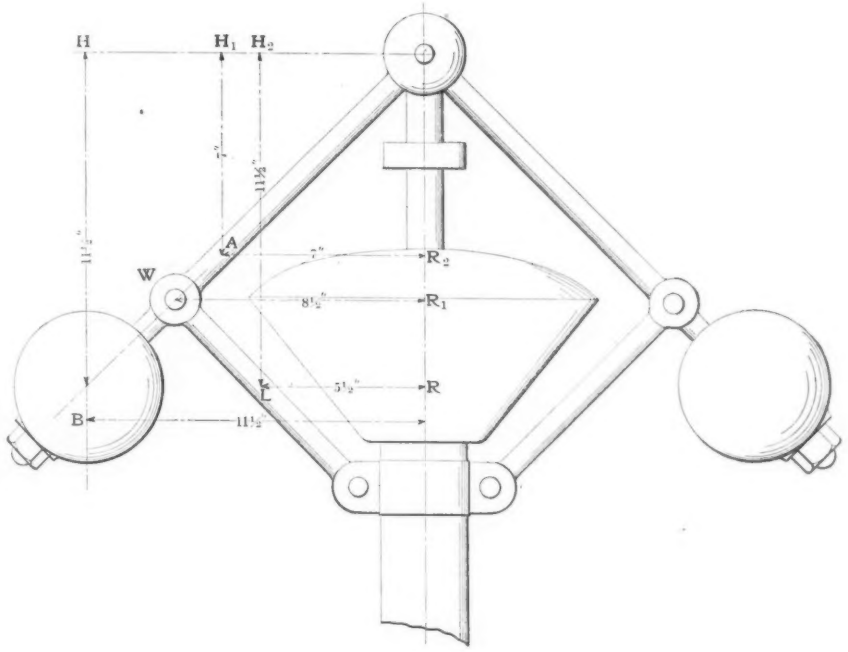
of each upper arm,

$$\frac{0.00034 \times 5 \times 7 \times 132^2}{12} =$$

16.988 *pounds*;

and of each lower arm,

$$\frac{0.00034 \times 2.5 \times 5.5 \times 132^2}{12} =$$



THE GOVERNOR IN DIAGRAM

6.788 *pounds*;

The moments of these forces about the point of suspension are, for the ball,

$$113.546 \times 11.5 = 1305.779;$$

for the upper arm,

$$16.988 \times 7 = 118.916;$$

and for the lower arm,

$$6.788 \times 11.5 = 78.062.$$

The sum of these centrifugal moments is

$$1305.779 + 118.916 + 78.062 = 1502.757,$$

which must likewise be the sum of the weight moments when the governor is in equilibrium.

To proceed with our calculation, the moment of the weight of each ball about the point of suspension is

$$20 \times 11.5 = 230;$$

of each upper arm,

$$5 \times 7 = 35;$$

and of each lower arm,

$$2.5 \times 5.5 = 13.75.$$

The sum of these weight moments is

$$230 + 35 + 13.75 = 278.75.$$

Therefore, the moment of the counterpoise must be

$$1502.757 - 278.75 = 1224.007.$$

Now, regarding the dead weight at the axis of rotation, the energy in the form of centrifugal force necessary to raise this weight to a plane of equilibrium may be considered as applied at the point of juncture of the lower arm with the upper, or the point W in the figure. The effect of the dead weight, then, so far as its influence in the direction of gravity is concerned, is precisely the same as though it were concentrated at the point W. Consequently, the value which we have obtained for the moment of the counterpoise, 1224.007, must be the product of all the dead weight at the center of rotation multiplied by the radius $W R_1$. The requisite dead weight, therefore, would evidently be

$$\frac{1224.007}{8.5} = 144\ \textit{pounds}$$

and so the weight of the counterpoise would have to be increased

$$144 - 106 = 38\ \textit{pounds}.$$

The objection might reasonably be advanced at this point, that the amount of added weight determined here as a result of our calculation could only partially achieve the object aimed at, that is, an engine speed of 110 revolutions per minute, in actual practice; and the argument might be urged in support thereof, that instead of the governor being brought up to the higher speed through some external agency, it would itself have to be depended upon to provide a means whereby the energy necessary in driving it at the higher speed could be developed, and this it could do only by increasing the mean effective pressure on the piston through the medium of a later cutoff, which, in turn, would demand a lower plane of flotation than is contemplated in our mathematical process; all of which is perfectly logical and true.

As a matter of fact, if the weight of the counterpoise were increased only by the theoretical amount determined herein, the governor would be constantly reaching out for, but never quite attaining to, a sustained rate of motion of the required velocity, because the very fact of such attainment would imply the same point of cutoff and mean effective pressure which were only sufficient for the original speed.

Nevertheless, it would seem that notwithstanding this apparent sacrifice of speed in gaining a greater force of propulsion behind the piston, the net result would still be the attainment of the purpose which we originally set out to accomplish, namely, the development of an additional 80 horsepower; for a loss in one factor would seemingly be compensated for by a gain in the other. However, it is quite probable that the actual increase in weight necessary to meet the modified conditions, would not exactly agree with the amount we have figured out; so, after all, the process would appear to be a tentative one, and more or less a matter of experiment in any case.

Electric Power in Colorado

According to *The Engineer*, the total initial cost of the electrical power plants either already in operation or now in course of construction in Colorado is estimated at fully £4,000,000. The effect on the mining industry has been and is increasingly beneficial, by reason of the reduced cost of power. The cost of steam power at the mines and mills, depending, of course, on situation, accessibility from railroad, type of plant used, etc., is said to range from £20 to £60 per horsepower, on the basis of continuous use. The cost of electrical power at the same mines and mills is said already to range, or with its introduction will range, from 25 to 75 per cent. less. With irrigating enterprises, the reduced cost of electrically pumping water from the streams to fertile lands as yet unutilized will obviate in many cases the construction of irrigation canals of great mileage.

Orifices for the Measurement of Water

Discharging into Air or under Water, Suppressing Contraction, and the Actual Discharge from Differently Formed Apertures and Ajutages

BY FRANKLIN VAN WINKLE

Orifices for measurement of water are generally placed in a vertical side of a tank or reservoir, though they may be placed in the bottom. When placed in the side of the reservoir, the upper edge of the opening should be completely submerged, and generally speaking, the head

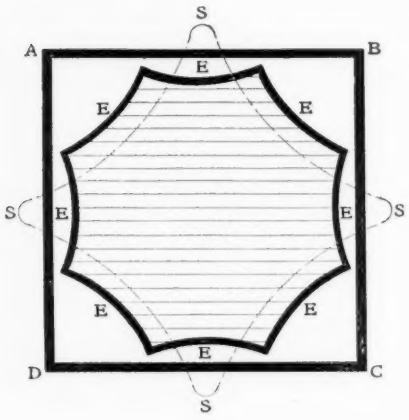


FIG. 1

on the orifice should be three or four times its vertical hight; otherwise, there will be interference in the formation of complete contraction. Contraction causes only the inner corners of an orifice in thin plate to be touched by the escaping water, and the issuing jet for some distance beyond the contracted portion retains the form of the aperture. When the orifice has uniformly sharp edges, the issuing stream from a round, square, rectangular or triangular orifice presents the appearance of a beautiful crystal bar.

Any tendency to assume a twisted form is indicative of unequal contraction of the sides, which may be due to the nearness of the aperture to the bottom or adjacent sides of the reservoir or to unequal finish of the edges of the aperture. The convergence of filaments in the reservoir in flowing toward the aperture, if not perfectly balanced on opposite sides, tends to impart a twist to the issuing stream, so that very little encouragement from lack of symmetry of the edges of the aperture or from the other causes mentioned results in a twisted form of jet. A perfectly symmetrical stream without twist is generally indicative of the existence of proper conditions for making measurements, although a solid stream having a small degree of twist beyond the contraction may be considered as yielding fairly satisfactory results.

A circular orifice with full contraction gives a jet always circular in section, as it advances until it is broken up into globules due to the varying velocities of different parts of the jet and the resistance of the air.

Fig. 1 illustrates the transformation of forms of a jet from a square orifice, illustrated in D'Aubuisson's "Treatise on Hydraulics." The jet is square at the orifice *A B C D*, assumes the shaded form *E E E E E E E E* a short distance beyond the contracted vein, farther on the form of a hollow-sided square *S S S S* shown by the broken lines, and continues to assume new forms until its solidity is destroyed.

Orifices with Submerged Discharge

When an orifice discharges under water, as the orifice *A B*, Fig. 2, discharging from the reservoir *C* into the tank *D* in such a manner that all sides of the orifice are under water, then the discharge is said to be submerged. The effective head causing flow is the difference in level *H* between the surfaces of the water in *C* and *D*. If the orifice has sharp inner edges, fulfilling the conditions of an orifice in thin plate, then it is found that the discharge rated on the head *H* will be very nearly the same as though the orifice discharged into the air with the same head *H*, measured from the surface of water in the reservoir to the center of the aperture.

The most carefully conducted experiments indicate that the smallest orifices under small heads give submerged discharges of less than 1 per cent. below free discharge into the air, and that when the orifice is as large as one square foot, excepting for very small heads, the difference is not appreciable. For all practical purposes a sharp-edged orifice with submerged discharge may therefore be regarded as having the same per cent. of theoretical discharge as though discharging freely into the atmosphere with a head due to the difference in level *H*, Fig. 2.

Ordinary sluice gates partly raised for admission of water from a raceway to a power plant, or for discharging waste water through dams, present examples of orifices with submerged discharge. But the coefficients for apertures in thin plate should not be applied in estimating such discharges without taking into account the extent to which the sides of the orifice deviate from the orifices in thin plate, for the reason that any rounding or thickening of the sides of an aperture tends materially to increase the discharge.

It may, however, be taken for granted for all forms of apertures that their coefficients for submerged discharges, with any given difference in head will be the same as discharging freely into the air under the same head measured to the center of the aperture.

Suppression of Contraction

In the foregoing discussion of outflow through orifices in thin plate, we have assumed that the issuing jet is curved and contracted beyond the aperture as a result of naturally converging paths of particles of water as they approach the aperture. The natural convergence and resulting contraction will not take place to the fullest extent if the inner sharp edges of the orifice are nearer to the surface of the water in the vessel or to the bottom or sides than about 1½ times the least transverse dimension of the orifice. Like-

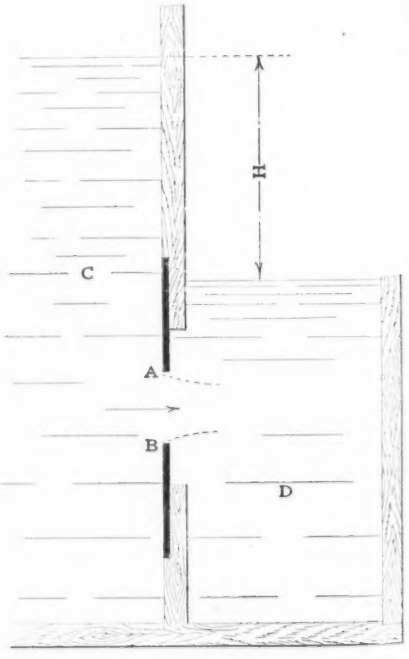


FIG. 2

wise if an orifice is made with its lower edge at the bottom of the vessel, as shown in Fig. 3, contraction is suppressed at the lower side of the issuing stream as the water passes along the bottom in a path *A B* at right angle to the vertical side *C D* of the vessel, forming no contraction at

the lower side. This is called incomplete, or suppressed, contraction. The same thing occurs to some extent if the lower edge of the orifice is placed a short distance above the bottom, as shown in Fig. 4. If the aperture is made with one side against the side of the vessel, as shown in Fig. 4 at *D*, then contraction will be suppressed next to the side of the vessel; and if placed in the lower corner as at *A*, suppression will occur both on one side and the bottom of the jet.

In each of these cases the effect of increasing the cross-section of the jet discharging under a given head results in increasing the discharge beyond what it would be if complete contraction took place. This fact has been frequently demonstrated in tests of apertures, the discharges of square apertures with contraction suppressed on one side increasing their discharge about 3½ per cent., and with contraction suppressed on two sides, 7 to 8 per cent. For rectangular orifices of such proportion as are obtainable by partly raising an ordinary sluice gate, it is found that suppression of contraction on the bottom side only may increase the

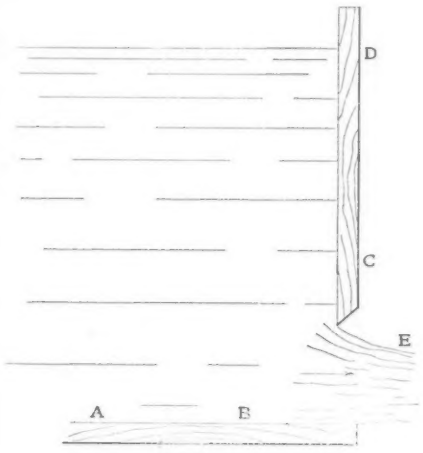


FIG. 3

discharge from 7 to 12 per cent., and that the coefficient of discharge may exceed 0.75 when suppression takes place on two ends and the bottom of the orifice, the coefficient increasing for a greater head.

From the foregoing it must be evident that in order to obtain accurate results in gaging water by orifices, any suppression of contraction should be avoided, not only on account of the difficulty of finding coefficients apparently suitable to a case in hand, but also from the uncertainty of identifying the conditions affecting the flow.

Discharge from Apertures

Apertures in thin plate and orifices having sharp, square edges of such thickness that the issuing stream comes only in contact with the inner edges of the orifices are the only kinds to be relied upon for measurement of water, unless the discharge of the particular aperture under consideration has been actually tested or compared with a standard orifice in thin plate. In all other forms of aperture the liquid-discharging stream touches the sides of the aperture to greater or less extent and is therefore seriously interfered with by the greater or less roughness of the surface.

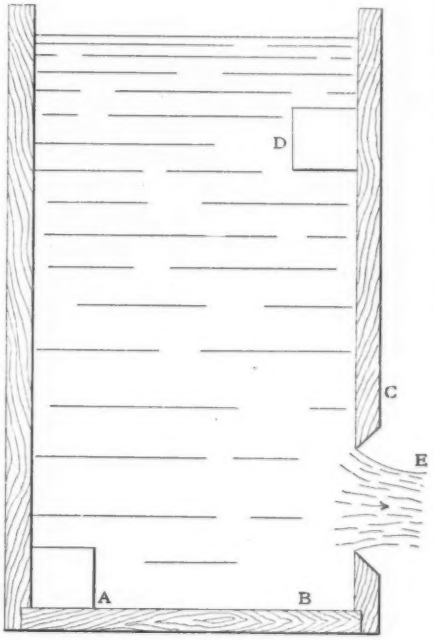


FIG. 4

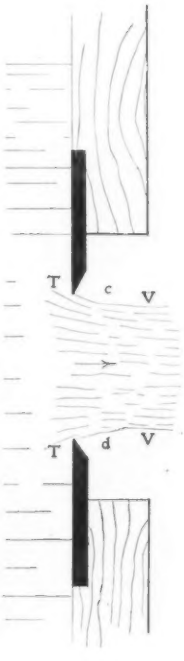


FIG. 5

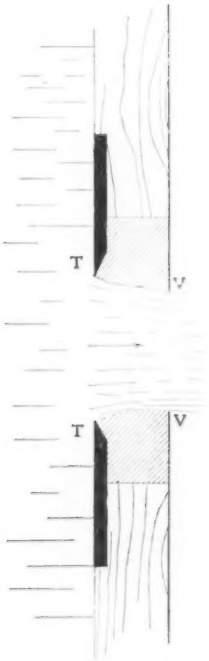


FIG. 6

Many different forms of aperture have been devised with the purpose of increasing discharge, but those which concentrate the outflowing jet most nearly to the form of the natural curve assumed by the contraction of the jet from an aperture in thin plate come nearest to imparting as high a velocity as the thin-plate aperture does to its most concentrated portion of the issuing jet. It would seem, however, that the form and properties naturally assumed by the vein from the aperture in thin plate should not be expected to be surpassed when we take into account the fact that it concentrates as much as 98 per cent. of all of the velocity due to gravity in its discharge, leaving only 2 per cent. of the theoretical 100 per cent. for overcoming the friction of approach to the aperture and the reacting resistance of the atmosphere.

These and other characteristics, as form, size and velocity of the contracted vein issuing from thin-plate orifices, should always be borne in mind in considering any feature of other forms of aperture. Because it is customary in designating the size of an aperture to quote the size with reference to the breadth or

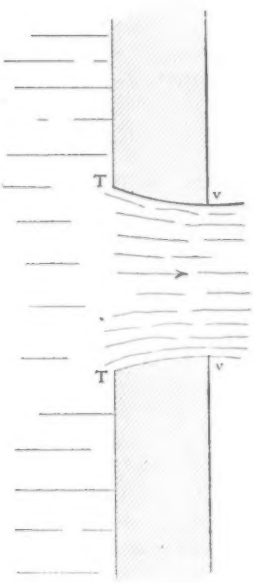


FIG. 7

FIG. 8

diameter of its smallest part, the per cent. of the theoretical efficiency of the aperture in thin plate must of necessity be quoted on the basis of the size of that very portion which influences the water of the reservoir as it approaches the opening. Referring to Fig. 5, which shows an aperture in thin plate, it is evident that the presence of material filling the spaces *c* and *d*, as shown in Fig. 6, would tend only to retard the filaments touching the curved portion.

Fig. 7 shows the same size and form as Fig. 6. Being a complete aperture in itself, its size would usually be quoted as the breadth or diameter of the smallest part *V V*. It is therefore natural to expect that, on the basis of the measurement of the throat, we should have an aperture discharging nearly the 98 per cent. velocity and quantity which we know to be true of the contracted vein *V V*, in Fig. 5. Comparing the aperture shown in Fig. 7 with that shown in Fig. 5, we have the

same actual aperture $T\,T$ next the water in the reservoir and the same diameter $V\,V$ of contraction in each, and we will have the same discharge from each excepting that the discharge, Fig. 7, will be decreased accordingly as the walls of the aperture touch and retard the issuing

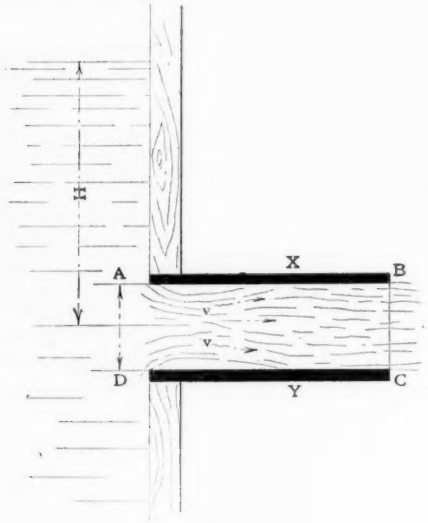


FIG. 9

vein. Another feature worthy of attention is that the discharge will not be increased, but will be diminished by rounding or beveling off the corners $T\,T$, as indicated by the dotted lines in Fig. 8, nor will any other modification of the

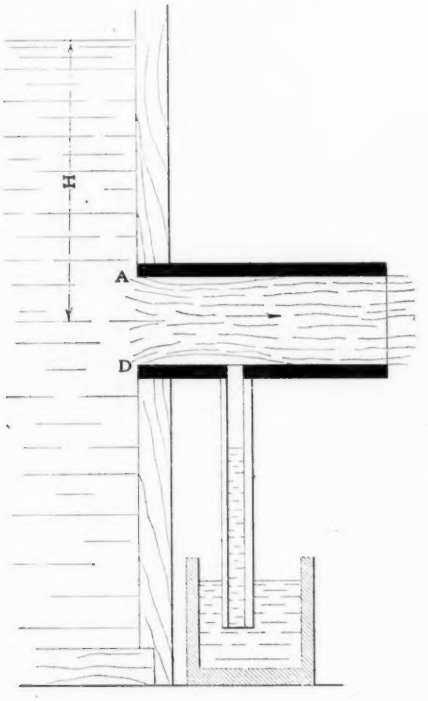


FIG. 10

natural curve of approach to the contracted vein yield as high a velocity.

When the inner edges of a square-edged orifice are enlarged by rounding them, we see that the contraction is modified, and although we have virtually increased the entrance end of the aperture, we have not obtained a proportionate increase of discharge due to the aperture in thin plate of diameter equal to the diameter of the enlargement. If the discharge is taken with reference to the smallest diameter $V\,V$ of the aperture, a larger coefficient will result, but will be less than the coefficient obtained for the natural contracted vein $V\,V$ of an orifice in thin plate.

In forming judgment of the coefficient of discharge of an aperture, its resemblance to the standard aperture in the curvature and contraction of the jet should be taken into account, remembering that the percentage of discharge taken with reference to the largest dimension, if at the entrance side, may be as small as 62 per cent., and taken with reference to its smaller end, if at the discharge side, may be as much as 98 per cent., these being the respective coefficients of the standard orifice in thin plate and of the

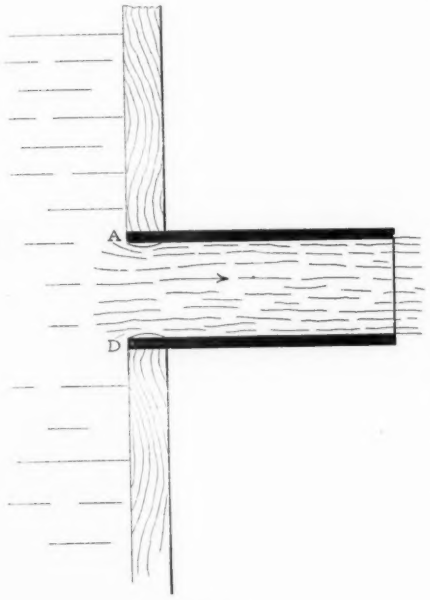


FIG. 11

contracted vein issuing from an orifice in thin plate.

Ajutages Create Vacuum and Increase the Discharge

An ajutage may be described as a tube inserted in an orifice. When an orifice in thin plate, such as $A\,D$, Fig. 9, is provided with a cylindrical adjutage tube, $A\,B\,C\,D$, 2½ to 3 diameters long, there is an influence which does not exist without the tube and which increases the flow materially. In the beginning of flow, contraction occurs, but after the particles have assumed parallel paths at $v\,v$, as in the *vena contracta* of flow through thin plate, they diverge, filling the tube again at $X\,Y$; the distance of the points X and Y from the aperture $A\,D$ depends upon the head H and the diameter of the tube, but is generally equal to 2½ to 3 diameters from the inner edge of the orifice $A\,D$. As soon as this occurs, any air which in the beginning of flow became imprisoned between the contraction and the tube is impelled forward and discharged, forming a vacuum around the contraction.

Observation of the action in ajutages made of glass tubing show that the void space formed around the contracted vein

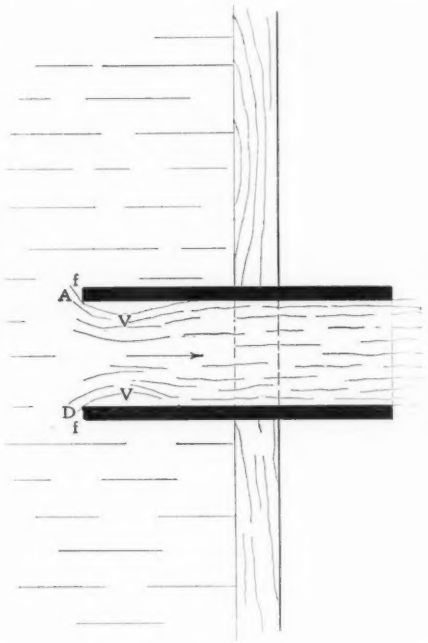


FIG. 12

is soon filled by expansion of the issuing jet, and the continuance of a partial vacuum near the inner end of the tube is clearly demonstrated by the fact that by making connection to a vessel containing water it will lift a column of water a considerable hight, as shown in Fig. 10. We then have the condition of flow within the tube indicated in Fig. 11. Paths of

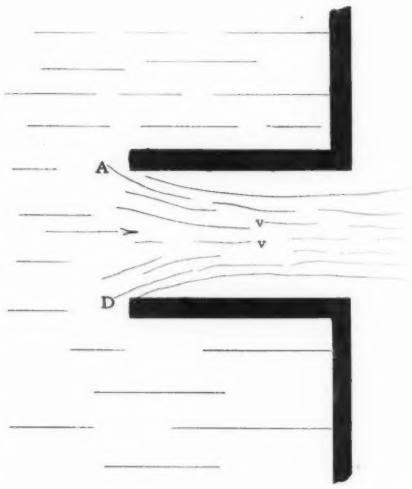


FIG. 13

particles approaching the aperture are parallel almost all the way back to the entrance and create less contraction; and in addition to atmospheric pressure on the surface of the water tending to increase the velocity of particles toward the vacuum space, atmospheric resistance

opposing the discharge from *B C* combines to increase the size of the issuing jet. This results in less velocity of jet, but it increases the discharge. An ajutage of this kind, if made only large enough for the suppression of the contraction and without increasing its length to

When shorter outward-projecting tubes are used than of lengths necessary for creating a partial vacuum, then the flow is not increased above the flow obtained by the orifice in thin plate when taken with reference to the orifice in the side of the reservoir, and they will not yield

is evident that the discharges from *a* and *b* will be nothing different than the discharge of an aperture in thin plate yielding about 62 per cent. of the theoretical discharge of their entrance apertures. If the sides of the short tube *c* are made to converge to the point where

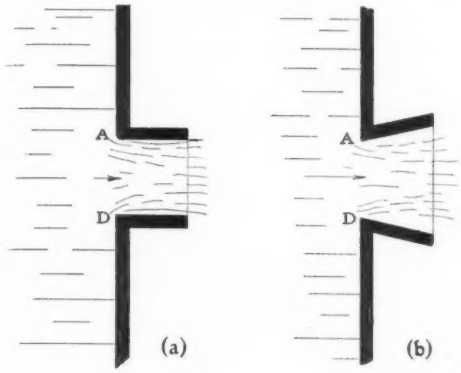


FIG. 14

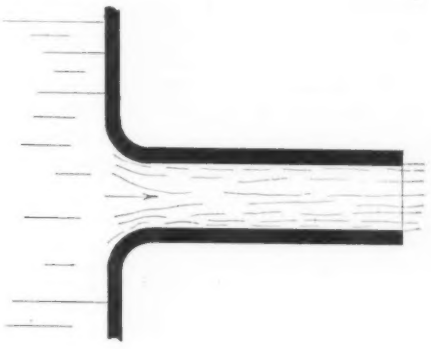


FIG. 15

that point where it becomes a pipe which would offer frictional resistance, will increase the capacity of discharge of the entrance orifice *A D* more than 25 per cent., so that its actual discharge will be about 82 per cent., in place of 62 per cent., of the theoretical discharge due to the head *H*.

If the tube projects into the reservoir, as shown in Fig. 12, the discharge will be 72 per cent. of the theoretical, a reduction of about 12 per cent. of the net discharge shown in Fig. 11.

But if the inward-projecting tube, Fig. 13, is so short that the entrance *A D* acts as an aperture in thin plate with natural contraction, it is found to have a coefficient of discharge of only 50 per cent., as against 62 per cent. obtained by placing the aperture directly in the vertical side of the vessel. It may be said generally of inward-projecting tubes of various forms, that they yield less discharge than when the entrance end is flush with the side of the reservoir. The contraction *v v*

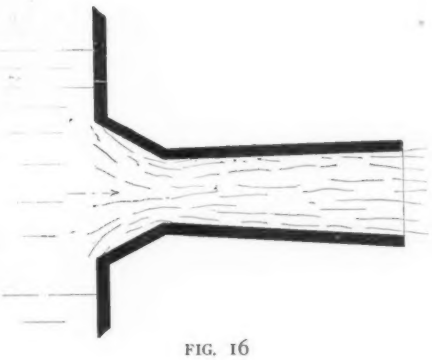


FIG. 16

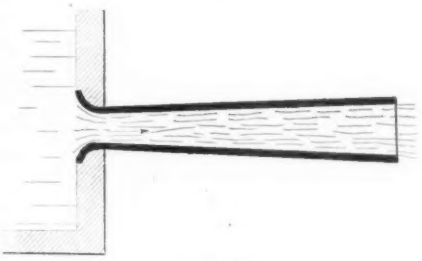


FIG. 17

they just begin to encroach upon the contracted vein, then we may expect, as in Fig. 7, that the discharge considered with reference to the size of *A D* will be close to 62 per cent., and considered with reference to the size at the contracted vein, it may be near to 97 per cent. The best results obtainable, when actually touching the contracted vein, are when the angle of convergence is 16 degrees, which would yield 58 per cent. of the theoretical discharge of *A D* and 90 per cent. taken with reference to the size of the small end of the adjutage.

If, however, an aperture, such as shown in Fig. 7, has an ajutage, as shown in Fig. 15, of sufficient length to cause a partial vacuum to be formed at the place of contraction, the velocity and discharge may be increased beyond the amount due to the natural contracted vein. By combining converging and diverging ajutages, like *b* and *c*, Fig. 14, Venturi found that the reduced velocity of a converging orifice, having a coefficient of

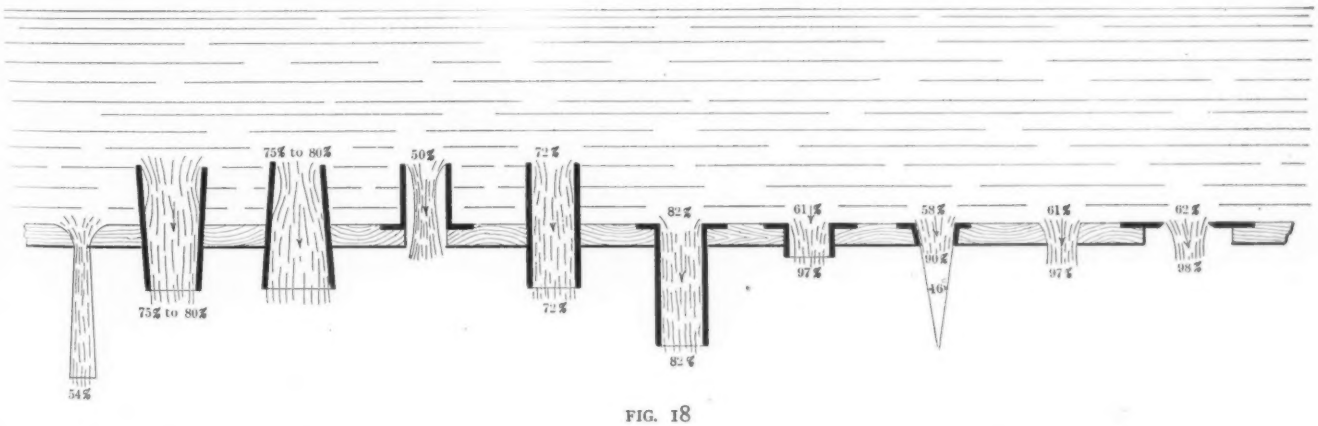


FIG. 18

is smaller than the ordinary orifice in thin plate, indicating a greater convergence of the lines of direction of filaments *f f*, Fig. 12, approaching the aperture *A D*. The coefficients for inward-projecting tubes of various forms may be found from inspection of Fig. 18.

quite as much when considered with reference to the coefficient of discharge of their contracted vein.

In Fig. 14 *a* represents a short cylindrical ajutage with parallel sides, *b* a short ajutage with divergent sides, and *c* an orifice with convergent sides. It

about 90 for its smallest part, if compounded with a diverging tube, as shown in Fig. 16, could be increased so as to apparently augment the force of gravity and yield a discharge for the smallest section in excess of the velocity due to the head.

With a tube similar to Fig. 17, but with

less perfect contraction and the sides of the diverging tube at an angle of about 5 degrees 6 minutes, Venturi obtained a coefficient of discharge of 1.46, computed for the smallest diameter of the ajutage. Venturi's experiment was conducted under a constant head of 2.89 feet. The smallest diameter of the ajutage was 0.1109 foot, and the length of the divergent tube was nine diameters, i.e., 0.9981 foot; the diameter of the discharging end of the ajutage was 0.1825 foot, and its area therefore over 2.7 times the size of the most contracted part. Had the coefficient been computed with reference to the discharge end of the tube, it would therefore be only

$$\frac{1}{2.7} \times 1.46 = 0.54 +$$

Comparing the discharge at the contracted portion with the coefficient of the contracted vein from an aperture in thin plate, we have the ratio 1.46 to 0.98, i.e., Venturi obtained a velocity for the most contracted portion of the tube which would be about 1½ times the velocity at the contracted portion of the vein issuing into the atmosphere from an aperture in thin plate. The increased velocity and discharge are due to the occurrence of a partial vacuum near the inner end of the adjutage. Pressure of the atmosphere on the water in the reservoir is thus increased, so that it is equivalent to increasing the head, resulting in increased flow through the contracted portion. But this increase is only local and may be regarded as only incidental of passage to and through the contracted portion, for before discharge from the tube can take place the velocity past the vacuum space is reduced again both by the enlargement of the tube and in effecting a discharge against atmospheric pressure, and by comparing the final velocity and cross-section of the discharge with the final discharge of an aperture in thin plate, it will be seen that the coefficient of final discharge, viz, 0.54, is less than that of the contracted discharge of thin-plate aperture, which is 62 per cent., and the actual discharge to the atmosphere is considerably less for a given size of discharge pipe than when the adjutage is cylindrical, as shown in Fig. 10. The experiment is valuable, however, in demonstration of the fact that the velocity of a jet passing through a contracted portion of a tube may become locally greater than the velocity due to the head.

Fig. 18 illustrates the leading forms of aperture and ajutages which have been referred to. They are shown as discharging from the bottom of a reservoir. The per cent. of the theoretical discharge attained in each case is given with relation to the size of entrance aperture or with reference to the size of the issuing stream, and in nearly all cases both are quoted.

Electric Power for Quarrying Marble

By C. T. Maynard

The electric system of the Vermont Marble Company and the application of it, especially in the quarries, may be of interest to readers of Power and The Engineer.

The main station, which is the water-power plant shown in Figs. 1 and 2, is located at the foot of Sutherland falls, on Otter creek, at Proctor. The effective head is 120 feet and the minimum flow is about 7000 cubic feet per minute, developing about 1000 kilowatts, but during ten months of the year the flow exceeds 15,000 cubic feet.

Plant Equipment

The power-house equipment consists of three Morris 1200-horsepower vertical turbines, direct-connected to three General Electric 750-kilowatt 480-volt 60-cycle three-phase generators making 514 revolutions per minute, and three 30-kilowatt 125-volt exciters. For furnishing 230-volt direct-current to operate four traveling cranes and several hoists and derricks in the marble yard, there is also in the power house a 150-horsepower induction-motor generator set. The switchboard contains three exciter panels, one

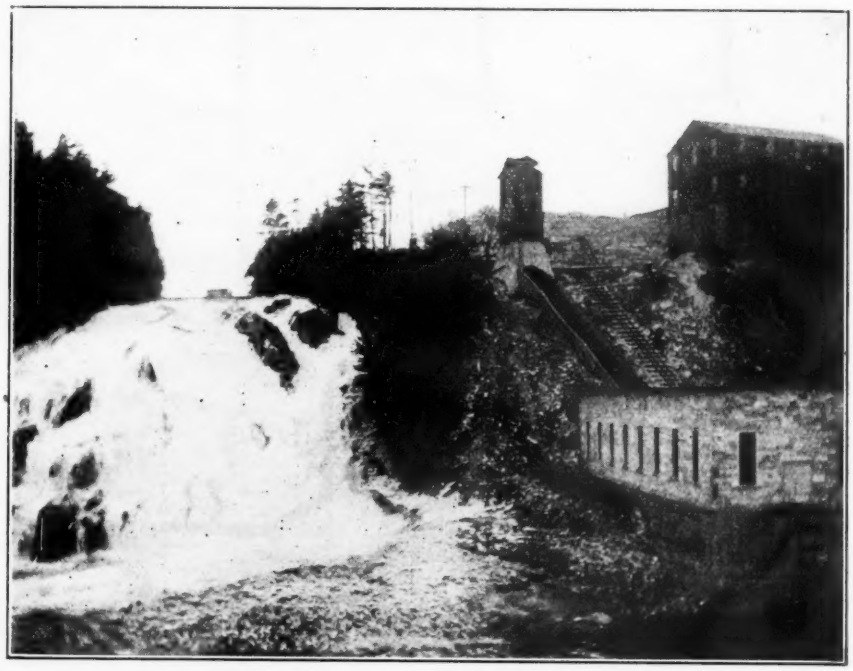


FIG. 1. MAIN POWER STATION AT PROCTOR

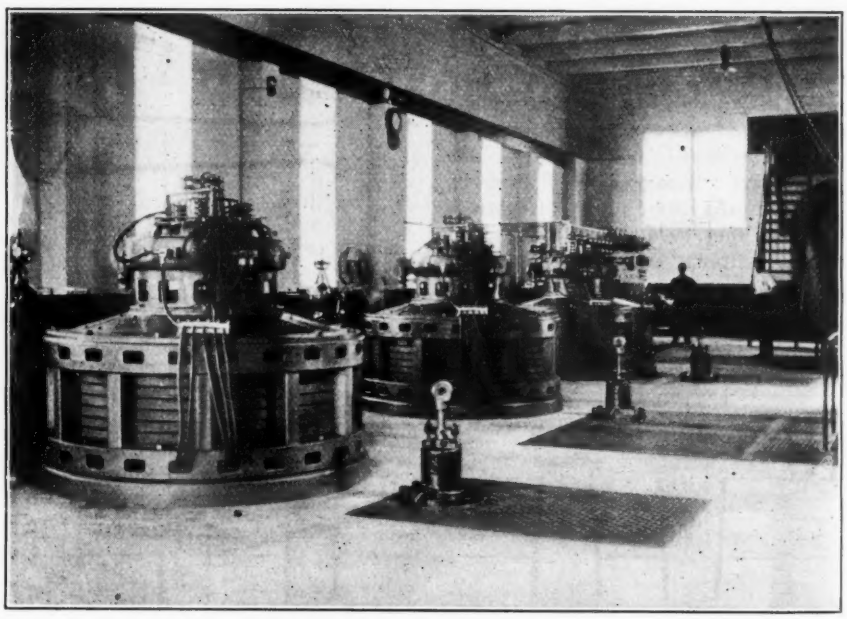


FIG. 2. INTERIOR OF WATER-POWER STATION

station panel, three generator panels, one Proctor mill circuit panel, one 480-volt panel for the low side of the West Rutland transformers, one series arc panel, one primary incandescent panel, two panels for the motor-generator set and one for the West Rutland instruments and 11,000-volt oil switch. The three West Rutland 480 to 11,000-volt step-up transformers are each of 500 kilowatts capacity and of the water-cooled type. At present two are run in open delta and the third is left as a "spare."

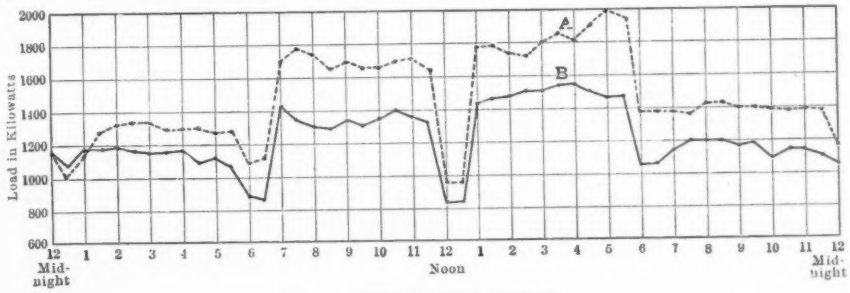


FIG. 4. TYPICAL LOAD CURVES

The power house is 90 feet long by 36 feet in width, and has two basements and a main generator floor. The water is brought to the plant in a penstock about 500 feet long and 9 feet in diameter. The turbines are located in the lower basement, and are fed by branches from the main tube. The step bearings, pumps, etc., are in the upper basement and the generators in the main room. The total length of each unit is 23 feet 1¾ inches.

Oil for Lubrication and Step Bearing

The guide bearings are fed with oil by gravity from storage tanks 16 feet above the main generator floor, and the oil is returned through piping in the upper basement to a White Star filter and from there into storage tanks, all in the upper basement, by a small centrifugal pump. The oil is then raised by a motor-driven triplex pump to the original storage tanks above the generator floor.

For supporting the weight of the three revolving units, three chain-driven triplex pumps supply oil up to 200 pounds per square inch to a steel step bearing, and this is helped out by a water bearing underneath supplied with water at penstock pressure, if desired.

Load Conditions

The turbine governors are of a special type made by the I. P. Morris Company. They are simple in design, having few parts that can get out of adjustment, and have given excellent satisfaction on a comparatively steady load, such as is carried. Fig. 4 shows in curves *A* and *B*, respectively, typical loads for winter and summer days, and also gives an idea of the steadiness of the load. Curve *A* was taken on January 3, 1908, and curve *B* on June 30, 1908.

Much of the time in winter it is necessary to run all three machines. The plant runs from sunset Sunday until midnight on the following Saturday.

The company lights the village streets with 30 series 7.5-ampere alternating-current arc lamps from a constant-current transformer, and the house lighting requires about 50 kilowatts capacity in transformers, which step down the voltage from 460 to 115. There are about 50 consumers in the village and all are on meters. The mill and yard lighting is furnished by about 2000 incandescents, 12 series alternating-current arcs and 40 multiple alternating-current arcs. From the Proctor mill circuit about 25 induction motors, varying in size from 10 to 250 horsepower, are operated, these motors taking in all about 700 kilowatts.

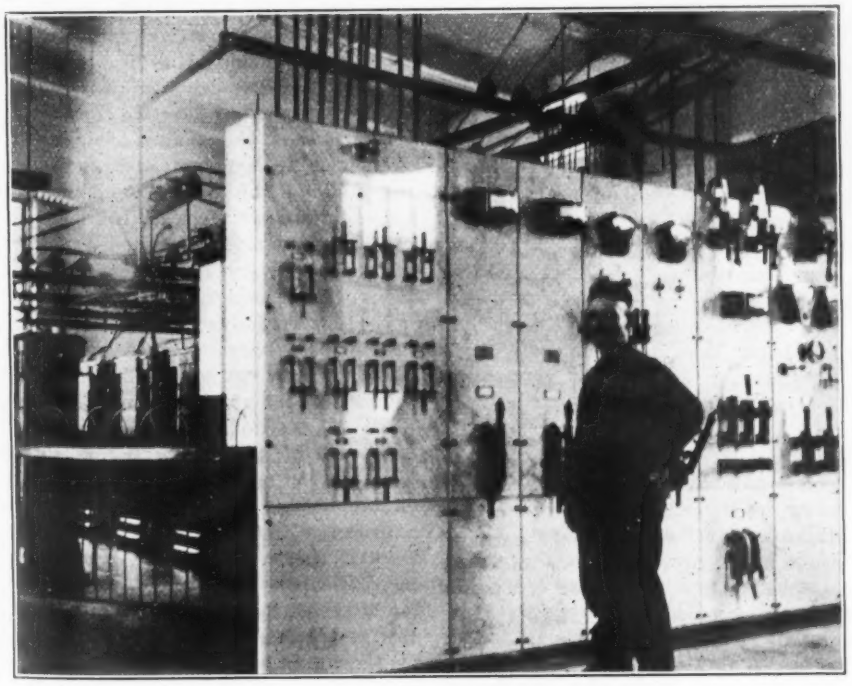


FIG. 3. IN THE WEST RUTLAND SUBSTATION

West Rutland Line and Substation

The West Rutland power line is five miles long and is of No. 1 hard-drawn copper. The line voltage is 11,000. At the West Rutland substation, the interior of which is shown in Fig. 3, the 11,000 volts is stepped down by six 150-kilowatt water-cooled transformers, one bank giving a secondary voltage of 3300 and the other 460. The 3300-volt circuit is used by three synchronous motors and the primaries of nearly all the lighting and power transformers in the quarries and the lighting transformers for the mills. The 460-volt circuit furnishes power for about 12 induction motors. Two of these are each of 112 horsepower capacity and of the variable-speed type used for hoisting. The others vary in size from 10 to 100 horsepower.

In the substation there are one 360-horsepower induction motor generator set and two constant-current transformers, one for the thirty 7.5-ampere series street lamps and one for the twelve 7.5 ampere series yard lamps. The motor-generator set supplies 230-volt direct-current power for one traveling crane, two 120-horsepower and one 55-horsepower series hoist motors, and several quarry and small motors besides a 13-ton mining locomotive. A direct-current distributing board enables any or all of the separate direct-current circuits to be opened. There is also in the rear of the substation two distributing panels for quarry and mill lighting. One panel has three 3300-volt plug circuits, and the other has nine circuits at 125 volts for nearby circuits.

There has just been installed at West Rutland a steam plant to be used as an auxiliary during low water at Proctor. This consists of a 700-horsepower, cross-compound condensing Corliss engine connected by eighteen 1¼-inch ropes to a 500-kilowatt 3300-volt 60-cycle three-phase General Electric generator and a 7½-kilowatt 125-volt exciter. The engine was made by the Nordberg Manufacturing Company. Provision has been made for phasing this generator in with the Proctor station by tying in on the 3300-volt circuit, and if occasion arises, West Rutland can also be phased with the main power station at Proctor by means of the 11,000-volt oil switch.

At Center Rutland the company has a number of mills and shops, and these are partly run by electric power. Two 75-kilowatt 230-volt direct-current generators driven by water turbines furnish light for the shops and power for two 25-ton traveling cranes and three constant-speed motors.

Motors for the Quarry

The future development and present interest in electrical matters in the company is centered in the equipment of quarry machines with electric drive. A greater part of the present machines are driven by steam, and the result is that these long underground openings are filled with steam which multiplies the possibilities of accident and makes it impossible to get the best results from the workmen. These quarries are about 300 feet in depth, and tunnels extend in all directions, some going as far in as 1200 feet. The quarry is filled with steam, gases and smoke, and the bottom is covered with mud and water. The help is mostly foreigners possessing but little intelligence, so that the conditions are far from being favorable for the operation of electric machinery.

To begin with, the maximum voltage seems to be limited to 250 for the sake of safety. The question that arises is the kind of motors to use. The motors must be of the variable-speed type. The series, shunt and compound direct-current motors, and the two-speed and the external resistance types of external motor have all been tried out. By far the best of all in every respect is the direct-current series motor. This statement may be surprising to many electricians who have always understood the induction motor to be the most substantial of all. The writer believes that for mill and shop work, or where there is a minimum attendance or constant speed demanded, or even in the quarry where there is resistance used only for starting, the induction motor is king of them all, but for quarry machines, on which the motor has to be fastened to a portable truck which is handled with as little care as a block of marble, the induction motor has proved a failure. The marble company has had from 12 to 25 General Electric series direct-current motors running for years on channeling machines, the only control being a rough semicircular resistance inserted in the line and on the truck, and it is safe to say that the dozen or more induction motors have given more trouble in six months than the series motors have in all the years they have been running. Even the shunt and series direct-current machines have given less trouble than the variable-speed induction motor.

One of the quarries has been equipped with a 35-horsepower Form L induction motor driving a triplex pump, and for this work it has done so well that a duplicate set has been ordered for another quarry, but in both cases the motor has a firm foundation. Perhaps it would be of interest to state some of the troubles that have been encountered with the induction motor in the quarries.

Troubles Encountered with Induction Motors

In the two-speed induction motor, six leads are brought out to a controller. These motors have been mounted on a small truck direct-connected to an Ingersoll air compressor to supply a rock drill. Over the motor is fastened the controller, with points for "off," "½ speed" and "full speed," and into this controller the six leads are brought. The controller has to be frequently taken off, and then there are six leads to get on the right studs. The runner sometimes does this, and the reader can imagine the many combinations and complications that could be made. It perhaps is well to state here that down in a deep, wet, muddy and dark hole it is very possible for even the troubleman to make a mistake in the proper connections, and especially when the six leads are not brought out from the motor in order.

After a little these same machines began to lag badly in speed when the load was thrown on, and it was found that all the rotors had their bars so loosened that they could be driven by the short-circuiting rings. This put the entire lot "out of business."

Next a channeling machine was reported as not running up to speed and at times hardly starting. Testing showed one of the three rotor legs open, and, after a good deal of trouble in tearing the machine apart and carrying it to the bank and to the machine shop, the break was found under the tape, where the strip had been sharply broken off close to the winding by the jar. Another channeler was reported hot, and it was found to be running single-phase, one fuse having been blown in some way after starting. A channeler motor that had been running only a couple of weeks gave a lot of trouble. It would scarcely start, but drew a heavy current and made a noise like a thousand bees. Tests showed the stator to be badly grounded, and the current was evidently partially short-circuited through the iron and gave no torque.

Another pair of motors would burn their leads off in the top of the machine about every two hours, because a sheet-iron cover was too tight. Removing the cover stopped the trouble. On another motor the collector rings got so loose that a steady arcing to the shaft by the grounded leg burned the shaft so badly that it had to be turned down and bushed under the rings. On another the studs and brushes were all shaken loose.

The Series Motor for Quarry Work

As a comparison refer to the record of the series motors, many of which have run years with no repairs except renewing the brushes and brush holders and smoothing up the commutator. As one field lead and one armature lead are permanently connected, there can be no change of direction of rotation, there is no multiplicity of leads, no complicated controller and only two brushes in very substantial brush holders. These motors have actually run partially filled with water on a rough shaking truck, working day after day, and that is what is necessary.

The Electric Locomotive

It will be remembered that a 13-ton mining locomotive was a part of the electrical equipment. This was made by the Baldwin Locomotive Works, and is equipped with Westinghouse motors and controlling apparatus. The two motors are each 35-horsepower series 230-volt machines, and can be operated in series or parallel. The locomotive has been operating about five months in a damp, steamy place and has given no trouble. The track construction is unique and is worthy of mention. The track itself is about 750 feet long, with a sharp grade. The locomotive runs back and forth on this track, drawing small flatcars on which, at the lower end, marble blocks are loaded. The cars of marble are taken to the upper end, where a derrick swings the blocks from the cars to a car on a track which runs on an incline of 45 degrees out of the quarry. This car is drawn out by a 120-horsepower motor at the top.

Current for the mining locomotive is brought to a point about midway between the ends of the track. A double-pole single-throw switch closes or opens the circuit. One side is grounded to both rails and the other is connected to a No. 1 bare hard-drawn copper trolley wire supported horizontally by trolley ears in barn hangers, which in turn are bolted to iron castings that are held by set screws to a 1¼-inch iron rod wedged in the marble floor and braced sideways. By means of the castings sliding up and down on the rods and being held at any elevation, the trolley wire can be kept at a proper elevation with respect to the track as the latter settles. Above and at the sides of the trolley wire 2-inch planking, fastened by U-bolts to the iron rod, acts as a protection to the wire and also to the workmen.

The Vermont Marble Company's electrical equipment has been almost entirely furnished by the General Electric Company, yet there are several Westinghouse and Western Electric motors and one of the Bullock type. Lightning rarely troubles the system, which is well protected by arresters, and short-circuits give almost as little trouble as the lightning. Shutdowns have been rare, as Sundays always allow repair work, so that the system has given general satisfaction.

For Burning Shavings and Sawdust

Presentation of the Best Methods for the Purpose, with Illustrations of Approved Types of Furnace, and Reasons for Their Use

BY OROSCO C. WOOLSON

In times past there has been a great divergence of opinion as to the best method of burning shavings and refuse in boiler furnaces. One of the old methods which was regarded as most feasible and practicable was to blow the shavings and sawdust directly down a chute into the furnace. This appears to be a quick and short method of firing the boiler with this material, and in many respects was ideal. If the fuel had been charged with inflammable gas, such an operation would no doubt have proved very satisfactory, because in that case the moment it had entered the furnace, it would explode into flame and serve its purpose of creating high temperature. But, as a matter of fact, the material was not of a nature to explode into combustion immediately, and from the very nature of its being blown in with an air blast, it is retarded in its explosion, the result being a low efficiency. A certain amount of oxygen is necessary above and around to burn fuel of this character, the same as is necessary with bituminous coal, but to admit this oxygen in large volume is fatal to the best economy, or if not economy, best general results. There may be conditions under which it is not the first consideration to obtain the highest economy from the refuse furnished, on account of the desirability of burning it for the purpose of getting it out of the way; but only to burn it partially, while distributing a large portion of it through the boiler chambers, tubes and smoke box, is not a desirable thing to accomplish, for if it cannot be thoroughly consumed, whether for economy or for a practical elimination of the material, then it becomes a wasteful proceeding. On the other hand, if every pound of this fuel is necessary as a fuel, then the most economical reduction is desirable.

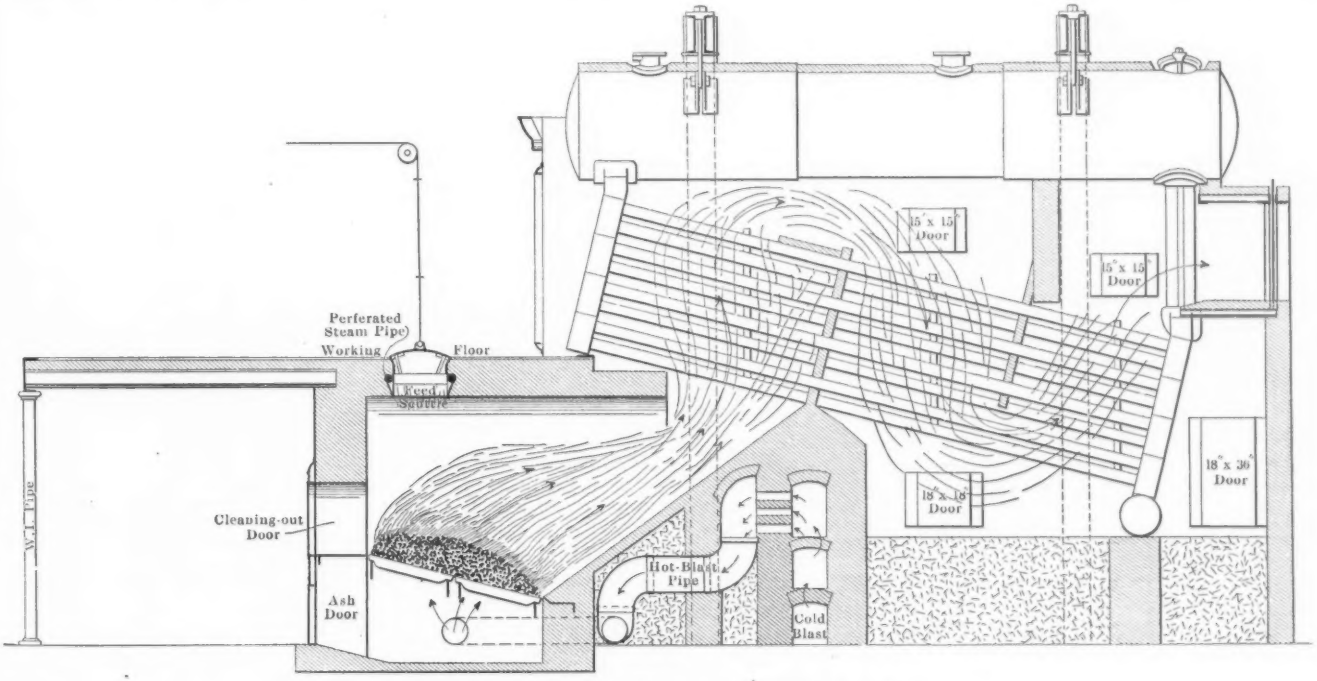


FIG. I. FURNACE DESIGN FOR HORIZONTAL WATER-TUBE BOILER

Dutch-oven Furnace Best for Shavings

Some writers conclude that the dutch-oven construction of a furnace for this purpose is best. This is quite correct. It is necessary to provide a reverberatory arch over this class of fuel, the same as is necessary in the best constructed bituminous-coal furnace. What is required is a high initial temperature, and this can only be obtained by the use of an arch, but the chamber under this arch must be of good liberal depth to admit of the fuel forming itself into a mound, under and up through which a strong blast is desirable to keep it dancing, and to avoid forming clinker as much as possible. The matter of clinker is not so troublesome with ordinary shavings and sawdust as is experienced with begasse, as with this fuel clinker will form like sheets of glass. In any event, the furnace should be provided with doors to facilitate cleaning out quickly and easily and tooling the fires whenever desirable.

Requirements of a Good Scuttle

To provide a good, substantial scuttle through the top of a fire arch is not a simple thing to do; neither is a simple scuttle all that is necessary, especially where a blast is used under the grates. In the horizontal water-tube boiler shown in Fig. 1, provision is made around the scuttle for a perforated steam pipe, to be located so that, either automatically or otherwise, when the scuttle is raised, it will admit a blast of steam to flow into the furnace around the scuttle opening, primarily, to prevent the blast blowing the flame up through the scuttle and, secondarily, to suck the fuel down into the furnace the moment it is shoveled over the opening. In this way the scuttle is open the minimum period of time to charge the furnace. The iron frame for this scuttle is made in such a way that the arch brick will come up fair and form a substantial joint around the casting and avoid any flange or projection of any kind above the working floor.

To the writer's knowledge there is no

arrangement more satisfactory than a scuttle of this kind for this purpose, for when the lid is in place, there is nothing projecting up except the bare wire cable or chain running over a pulley sufficiently high to be out of the way of a man's head and tools, and it does not prevent the fuel being dumped immediately around and upon the scuttle, so that when firing takes place, the mere act of lifting the scuttle by the use of a counterweight and having the blast then in operation around the scuttle opening, allows sufficient fuel to be drawn into the furnace almost by the time the scuttle is sufficiently raised. In fact, an excellent method of continuous feed is to keep the lid suspended over the scuttle continuously and keep a bank of shavings on top of the scuttle, which will effectually seal the opening, and yet a mere prod will sufficiently start the fuel dribbling down through the opening, the air or steam blast surrounding it preventing any back draft.

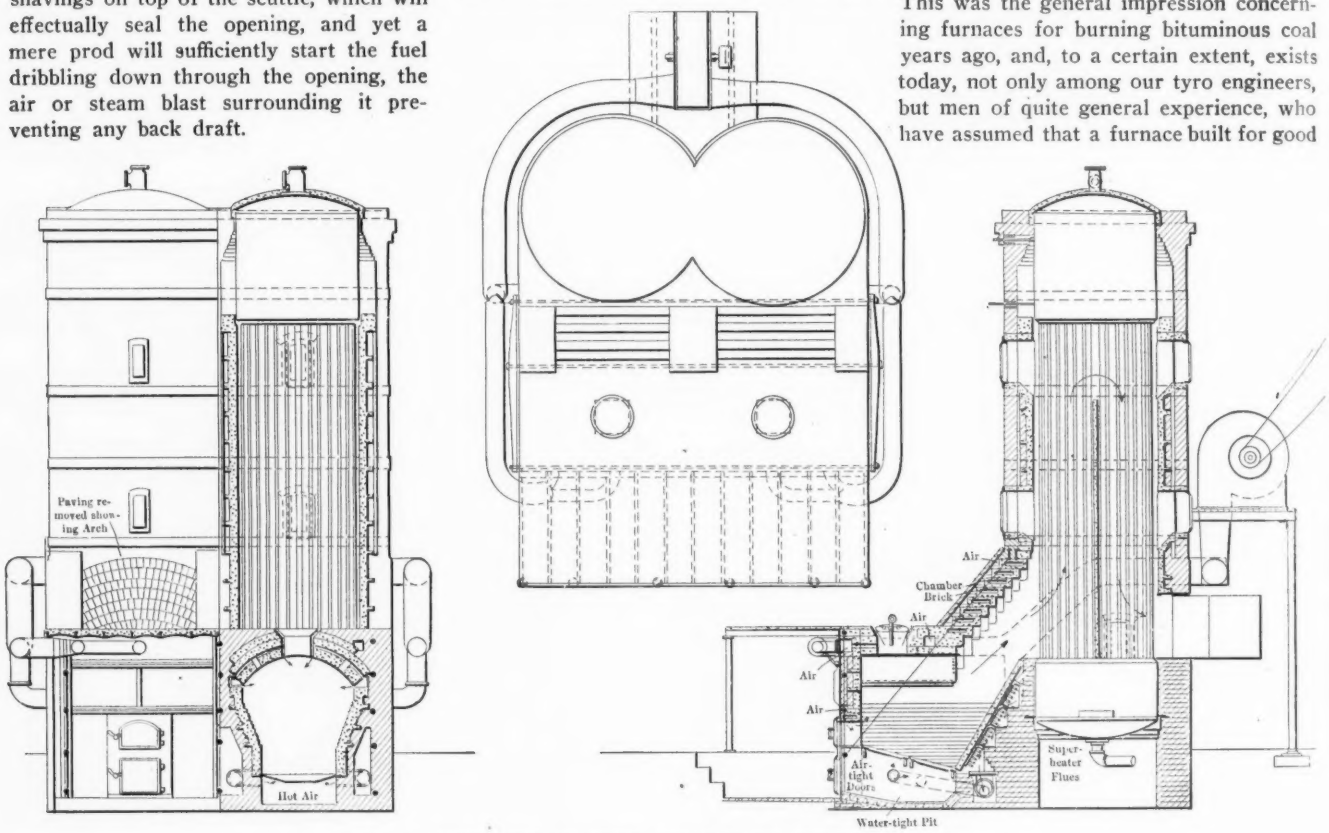


FIG. 2. SMOKELESS SHAVINGS FURNACE FOR VERTICAL BOILER

In the case of the upright water-tube boiler in Fig. 2 the same design of scuttle is employed, except that in place of the steam blast, provision is made to admit an air blast from a side duct of the regular blast apparatus. In this illustration are more clearly shown the necessary air passages circulating through the firebrick arch and discharging into the path of the gases as they ascend up and around the tubes. This pattern of chambered brick is one which the writer has had in use for many years, and it has proved highly satisfactory in many ways. It is a simple pattern for molding and forms a substantial arch. Its long life may be attributed largely to the fact that the bricks cannot become overheated by virtue of the air circulating all through their interior, and also to the fact that the discharge of air into the combustion passageway tends to carry the hot gases away; or in other words, forming, to a certain extent, an insulating film of air immediately on their faces.

Air Passages

The inclined paving immediately back of the grates is considered an improvement over the pipe passages shown on the horizontal boiler setting. As is quite clearly shown on this drawing, the air is brought into a top duct, passes along its length, then back through a second duct of the same character to the other end, and then through still lower ducts until it is finally discharged into a pipe which leads to both sides of the ashpit. The cast-iron plates which form a facing against which the firebrick paving is finally laid are provided with fingers all over their back faces around which the air must circulate. It will be noticed that the oxygen is brought into the ashpit on each side, one discharge being a little to one side of the opposite opening. A blast brought in from one side only or from the back side tends to concentrate the blast in some particular locality in the pit, which is not desirable.

Doors for the Ashpit and Furnace

It is a common practice to furnish doors, both for the ashpits and for the furnace openings, of the same design for blast-furnace conditions as for natural-draft conditions, but this should be regarded as poor design. To be consistent is a virtue, and to assume that a door with an ordinary fit is sufficiently good for a furnace that has a blast pressure behind it is not practical, especially when it is so simple a matter to provide the proper fitting. The door shown has been used for 20 years, and costs no more to make than any other door, yet is perfectly blast-tight when closed, under all the varying conditions of expansion and contraction.

Shavings Require Special Design of Furnace

It appears to be the general impression that a furnace for burning shavings and refuse is one of those simple things that any mason who can lay brick can build. This was the general impression concerning furnaces for burning bituminous coal years ago, and, to a certain extent, exists today, not only among our tyro engineers, but men of quite general experience, who have assumed that a furnace built for good results from anthracite is equally as good for bituminous coal, and yet the two fuel elements are as vastly different as bituminous coal and shavings. The conditions that are proper for bituminous coal are diametrically wrong for anthracite, and as time goes by these differences are being better understood and acknowledged, so that today our best bituminous furnaces are constructed on lines very different from furnaces for anthracite consumption, and the results are correspondingly better. The same is the case with furnaces for the material under discussion. Therefore, to build a furnace to give the best results in combustion, capacity and smokelessness, we must construct it on proper lines. Smoke from bituminous coal is, broadly speaking, simply and solely a condensa-

tion of the hydrocarbon gases, and to allow these gases to condense and pass through the chambers and tubes of a boiler and finally discharge themselves into the outer atmosphere is wrong in the fullest sense of the word, and the existence of such conditions can only be accounted for from the fact of there being ignorance on the part of the builder, or a wilful disregard of what is best for his own pocket and the comfort of the public. The same law holds good concerning the burning of shavings and refuse; the same condensation of unconsumed carbon takes place, which is due to wrong construction of the furnace that is intended to consume it, but there is no excuse for the existence of the one more than the other. So long as furnaces are constructed in the old haphazard way of assuming that such a furnace is to be simply a crematory for getting rid of a useless residuum, then we shall get smoke.

Special Design of Grate for Front Feed

The foregoing has reference to the proper construction of a shavings and sawdust furnace as a whole, with a flat grate having moderate openings, but Fig. 3 illustrates a grate designed especially for this fuel without reference to other construction of the furnace. As apparent, it is not a flat grate at all, but just the reverse, the object being to use it in a furnace where the shavings are either shoveled or shoved from the front through an ordinary fire door, or rather not an ordinary fire door, except in its position, because where fuel must go in from the front, an internally swinging door is preferable, so that as the shavings are shoved through under, it will of its own accord swing back down into position, or possibly remain up, banked up with fuel ready for the next charge, its form being such that there shall be a liberal supply of incandescent fuel left upon the bars or plates readily to catch up the fresh supply of fuel when it is fed in, and to provide a grate surface that shall project its air openings up into a body of fuel better than a flat grate. Where this furnace was first used cannot now be recalled by the writer, but it was somewhere in the West, and the results obtained were very satisfactory, so far as the mere grate surface was concerned. The depth of the sides of this grate being a matter of about 8 to 10 inches, its operation was such that by the time the fuel had wasted away sufficiently to uncover the top of the grates, there was still a good bed of incandescent combustible in the grate, which readily took up the fresh supply when shoveled in. These plates had round openings about ¾ inch in diameter, every 2 or 3 inches apart, the top row of openings being formed half in each plate, so that there was a discharge of air along the ridge of each section, and to keep this ridge or apex covered was a matter of experience in the proper running of the furnace.

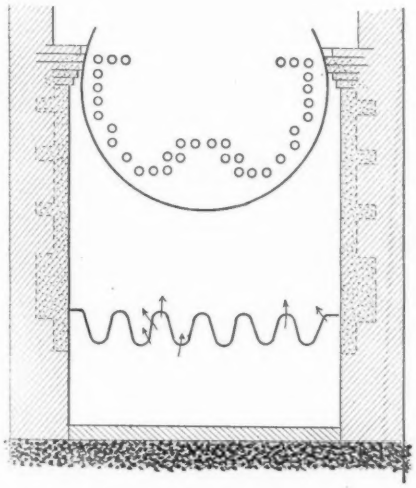


FIG. 3. GRATE DESIGNED FOR FRONT FEED

Long Transmission Line in Ontario

The Ontario Hydro-Electric Power Commission has awarded to the F. H. McGuigan Construction Company, Toronto, the contract for the construction of the transmission line which is to distribute power from Niagara Falls to various cities and towns in the province. The total price to be paid for the work is $1,270,000. The total length of the line will approximate 300 miles, and will be used to distribute power to Toronto, Guelph, Hespeler, Waterloo, Berlin, Galt, Woodstock, London, Ingersoll, St. Thomas, St. Mary's and New Hamburg. There have also applied to be included Windsor, Walkerville, Norwich, East Toronto, Weston and West Toronto.

There will be required in all considerably more than 3000 towers in the 300 miles of transmission line. Three cables, each suspended from a separate insulator, will form a single circuit. The greater number will be two-circuit towers, carrying six cables each, not counting the ground line or the line for lightning protection. The towers will be 550 feet apart, except where local conditions require shorter or longer spans. If aluminum is chosen as the material for the cable each cable will consist of seven strands bound together, the total diameter being ½ inch. The estimates call for a total of 994,800 pounds, or a little more than 497 tons of aluminum cable, the total mileage of cable being 1149 miles, not counting the ground line or the line for lightning protection. Twelve transformer houses will be required for this system, which when finished will be the largest and most complete in the world.

The total hight of the standard two-circuit tower will be 44 feet 6 inches, and it will be 16 feet square at the base. Each tower will be square, having its four feet resting in 7 feet of cement.

All the equipment to be installed is intended to carry a voltage of 110,000, which is greatly in excess of the voltage carried over any Canadian transmission line.

The standard spacing of the towers will be 550 feet from tower to tower, which may be varied to meet local requirements, as, for instance, at the Welland canal, which will be crossed by a short span upon towers of sufficient hight to give 150 feet clearance between the lowest conductors and the water level. Between Dundas and Toronto there are two water crossings which will require 800-foot spans, no extra hight, however, of tower being necessary. At the Credit river there will be another 800-foot span. In order to cross the Humber river there will be a span of 1250 feet. Near Brantford, where the line crosses the Grand river, there will be a 900-foot span. Where the line crosses other transmission lines and railways special towers will be erected.

The line as now planned, or the portion for which the agreement has been signed, covers western Ontario only. Eastern Ontario and perhaps northern Ontario will ask for the same privileges. To provide for this, there is a clause by which the same length of additional line may be erected upon the same terms. That is, 293 more miles of line may be built, making a total of 586 miles.

The wire used will be aluminum line, of which there will be 1,014,209 pounds, or about 507 tons; there will be 3176 towers, 66 feet high, and they will take 6554 tons of steel costing $621,000. There will also be 140,000 pounds of telephone wire used for the double telephone line to be strung on the towers. The contracts for the material have been awarded to Canadian firms.

Turbines for German Boats

The twelve new torpedo boats under construction for the German navy will be of about 610 tons, and will all be driven by steam turbines. It is planned to try four different types of turbine. The three boats which the Vulcan yards, near Stettin, are constructing are to be equipped with turbines of the Allgemeine Elektricitäts-Gesellschaft (Curtis type); the four boats which the Schichau yards of Elbing and Danzig have undertaken to build will receive turbines of Melms and Pfenninger; similar turbines are also put on board the small cruiser which the Schichau works have built to replace the "Greif." Of the five torpedo boats under construction at the Germania yards at Kiel, four are equipped with Parsons turbines and one with Zoelly turbines.—*The Mechanical Engineer.*

The Plunger Hydraulic Elevator

Description of a Simple Type of the Otis Freight Elevator with Hand Rope Control; Operating Valve Construction and Adjustment

BY WILLIAM BAXTER, JR.

The general arrangement of a simple type of Otis plunger elevator is shown in Fig. 263, which is a vertical elevation of a freight elevator provided with hand-rope control. The operating valve in this drawing is shown with a long lever to the end of which the hand rope is attached. The valve, as will be seen, is very simple, the supply water reaching it through the pipe *A*, which enters the upper end of the valve cylinder. From the lower end of the cylinder a pipe *B* connects with the upper end of the plunger cylinder, and through this pipe the water enters when the elevator ascends, and escapes when it descends. The escaping water passes out of the main valve through the bottom, and is carried off to the discharge tank through the pipe *D*. The operating lever *L* is used when the car runs at very slow speed, as is generally the case in buildings of three or four floors. For higher velocities of car it is necessary to substitute for the lever *L* other means of moving the valve, whereby greater movement of the operating hand rope is required to open and close the valve. If such means were not provided, the starting and stopping would be entirely too rapid. If the car speed is moderate, say 100 feet per minute, the valve is operated by means of a rack and pinion, in precisely the same way as the hand-rope operated valves already described as being used with cable hydraulic elevators.

In some cases freight elevators are arranged so as to carry passengers also, and on that account are run at a higher speed, and occasionally passenger elevators in buildings where economy of construction is considered are arranged to be controlled by a simple hand-rope operated valve. For such installations, the simple rack-and-pinion arrangement is not satisfactory because it will close the valve with too small a movement of the hand rope. For such service the valve is made with a double set of gears, the pinion that meshes with the rack being mounted upon a shaft that carries a larger gear, and that in turn meshes with a second pinion that is mounted upon the hand-rope sheave shaft.

When a lever-operated valve is used, the travel of the hand rope is varied by varying the length of the lever *L*, which is made about 3 feet long for very low speeds and as much as 7 feet for the highest speeds. When the lever is 3 feet long, the movement of the hand rope required to make a stop on the up trips is about 15 inches, and on the down trips about 10 inches. With the longest lever, about 7 feet, the rope movement to make

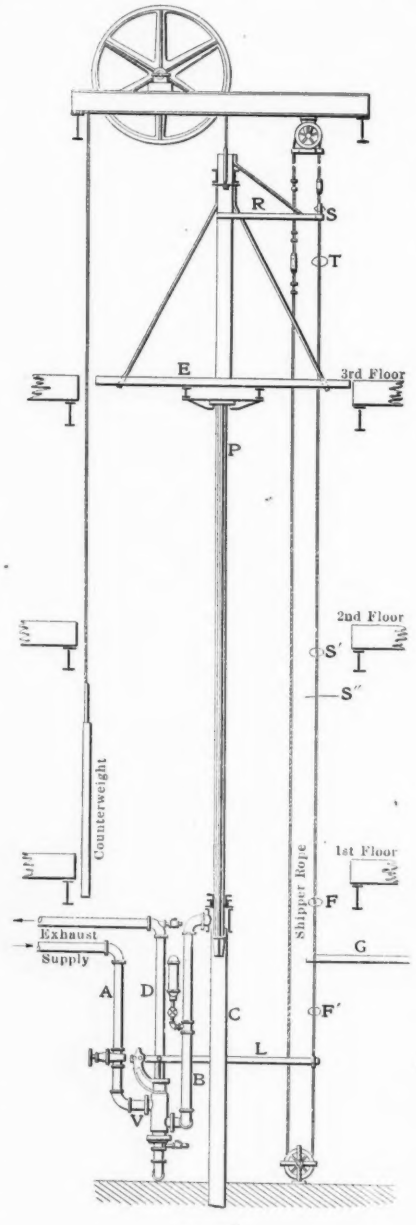


FIG. 263

a stop on the up trips is about 3 feet, and on the down trips about 30 inches. With the single-geared rack-and-pinion the rope travel required to stop the car is about 5 feet, which can be varied to some extent by changing the diameter of the hand-rope sheave, say from 4 to 7 feet. When a double-reduction gear is used the rope travel varies from about 9 to 18 feet, according to the car speed. If only the manipulation of the hand rope by the operator were considered, it would not be so important to vary the movement of the hand rope with the speed of the car, because with a little practice an operator could learn just how to manipulate the rope to make satisfactory stops; but the car is also stopped automatically at the top and bottom landings by the movement of the hand rope and this movement is effected by the car itself; hence, the travel of the hand rope required to stop the car must be made to conform to the car speed.

In Fig. 263 the elevator is represented as being level with the third floor, and the stop ball *S* on the hand rope is shown resting against the upper side of the arm *R*. Before the car would reach the top-floor stop the stop ball would be in the position *T*, and would be carried from that position upward to where it is drawn in stopping the elevator. On the downward trip the arm *R* strikes the stop ball *S'* when it is in the position shown, and carries it down to the line *S''*, to stop the car, and then the floor of the latter is even with the first floor of the building. If the length of the lever *L* is proportioned to the speed of the car so as to give the proper amount of hand-rope travel, the car speed will be cut down gradually until the car comes to a stop even with the floors of the building, without producing any noticeable shock. If, however, the hand-rope movement is too short for the car speed, the stop on the down trip will be very violent and on the up trip the car will not stop promptly, but will continue upward and lift the valve far enough, in an extreme case, to let water escape from the cylinder; as soon as the headway dies out, the car will drop back until the plunger strikes the water in the cylinder, when its backward movement will be stopped with a severe jolt. Even if the car does not run far enough above the floor to open the valve in the reverse direction, if it should pass above the floor any distance, the plunger will be drawn away from the water in the cylinder and on the return will be stopped suddenly when it strikes the water again. If the rope movement is made longer than necessary there will be no undesirable effect except that the time

consumed in stopping will be unnecessarily increased.

Adjustment of Valve Movement

When the elevator runs at a high velocity, it is generally necessary to provide means for adjusting the movement of the valve when it is opened, so that there may be no danger of imparting too high a speed to the car if the load is very light. With slow-running cars it is not necessary to provide such adjustment, because even if the car should run 50 per cent. faster with a light load there would be no objection, but if the normal car speed is, say, 400 feet per minute, and it should run 600 feet with a light load, some damage might be done, either when the car is stopped at intermediate floors, or when it is stopped automatically at the top floor. The means employed to adjust the running speed consist of stops placed on the hand rope, as shown at $F F'$, and a stationary stop G. The stop F controls the opening of the valve for the up trip, and F' controls the opening of the valve for the down trips. If these stops are set close to the stationary stop G, the movement of the hand rope is limited, and as a result the opening of the valve is reduced. Contrariwise, setting these stops farther away from G increases the opening of the main valve, and, therefore, the car speed, with light loads. There is no great danger of the speed being too great with full load, as elevators are not often so generously proportioned as regards the driving power as to be able to run away when fully loaded, but when the car is empty the driving power is sufficient to develop a speed much higher than the normal. This is more likely to be the case with the cable hydraulic type than with plunger elevators, because with the latter the weight that has to be lifted when there is no load in the car is much greater than with the former.

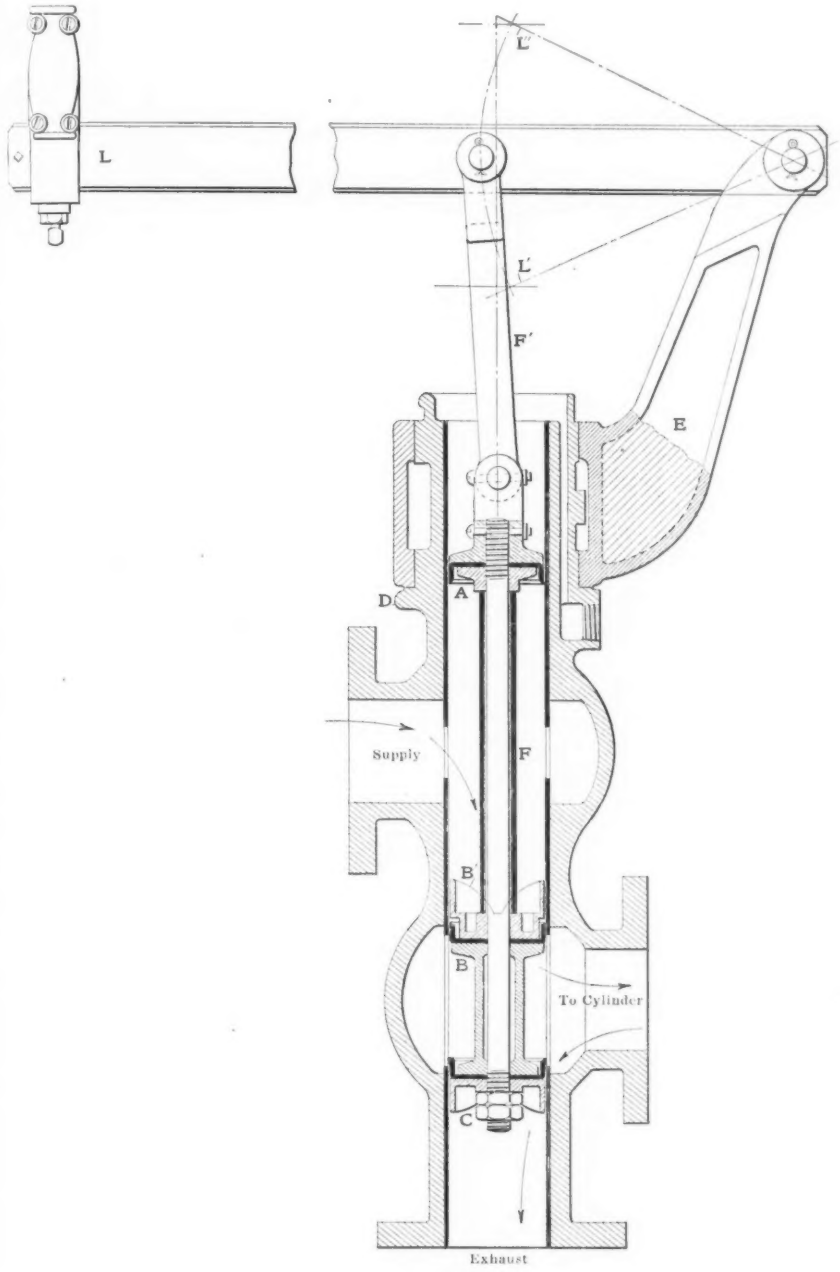


FIG. 264

Construction of Operating Valve

The construction of the operating valve shown in Fig. 263 is illustrated in Fig. 264, which is a vertical section through the center of the valve and its cylinder. The supply water enters through the upper inlet and if the lever L is depressed, it will pass by the piston B and, following the path indicated by the arrow, will flow into the pipe that connects with the top of the plunger cylinder marked B in Fig. 263. If the lever L is raised, the water can flow out from the cylinder and past the piston C to the discharge tank. The piston A serves to balance the valve and also to prevent the pressure water from escaping through the top of the valve cylinder.

The valve cylinder is made of cast iron and is provided with a brass lining within which the valve pistons slide, all of which is clearly shown in the drawing. The valve pistons are provided with leather-cup packings and heads to retain these in position. These heads are made with outer flanges cut away in a wide V-shape, as shown at B', so that when the valve is moved to close the port, the flow of water is stopped gradually. For high-speed elevators these V-shaped flanges are made so as to stop off the flow of water quicker than is necessary, and when the elevator is installed in the building they are adjusted by actual trial, the edges being filed off until the proper degree of smoothness in stopping is obtained. For very slow-running elevators it is not necessary to go to all this trouble, as the shape of the flanges can be made near enough to accuracy at the shop.

The brass lining of the valve cylinder is provided with numerous narrow ports opposite the outlet so as to hold the cup packings of the pistons B and C in place. Similar ports are provided opposite the inlet, but these are necessary only to permit easy removal of the valve when desired, and also making the whole lining in one piece. So far as the operation of the valve is concerned the lining could be made in two parts separated from each other opposite the inlet as much as might be necessary to permit the water to flow in. The arm E that carries lever L is made like the arm of the automatic stop valves described in connection with the passenger plunger elevator; that is, it is clamped to the upper end of the valve cylinder above the point D, this portion being turned to fit the bore of the arm E and its cap.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Wrong Boiler Setting

The two illustrations are of a boiler located in the plant at which I am employed. Fig. 1 shows the boiler as it was when first erected. The fuel used is natural gas and the boiler has been in use over a year, but was not worked very hard until about three months ago. The feed water is fed through the blowoff pipe, a thing I objected to when the boiler was set up, but I was not the chief engineer then, and the fellow who was in charge was able to talk the management into feeding this way.

Things went smoothly enough until we commenced to crowd the boiler, then scale began to collect at the end seam and around the blowoff pipe. A few weeks ago the feed pump gave out and I placed a larger one in its place. The result was that the mud collecting at the blowoff was driven to the other end of the boiler, resulting in a few days in a nice bag about 6 inches in diameter.

The illustration also shows the way the furnace was constructed. Note the slant of the fire bridgewall and the location of the bag. In Fig. 2 is shown the way I have changed things, not only the feedwater connections, but the furnace as well. I might add that we have only cleaned the boiler once since making the change, but found that the mud was near the blowoff outlet, while before it was in the front end of the boiler.

C. S. ROBINSON.

Independence, Kan.

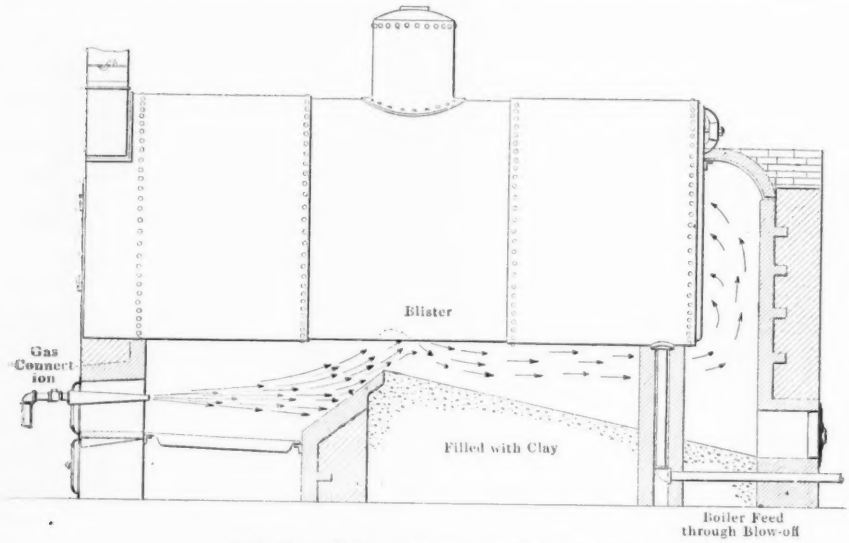


FIG. 1. HOW BOILER WAS FIRST ERECTED

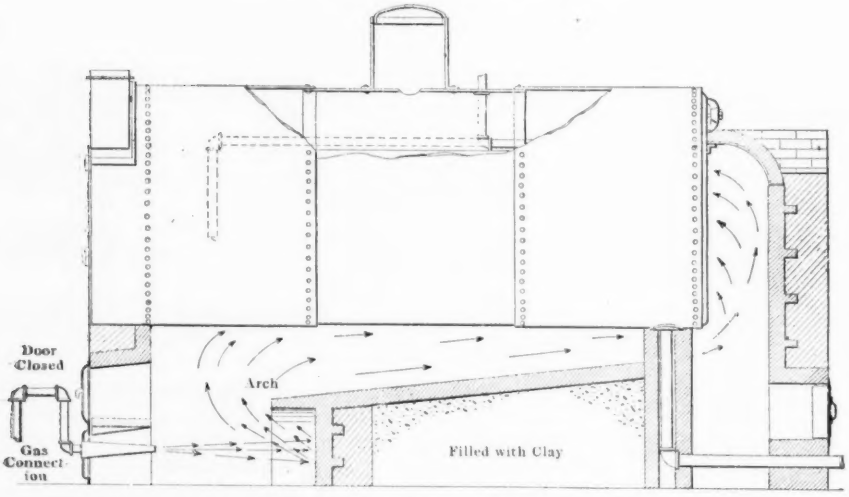


FIG. 2. SHOWING THE CHANGES MADE IN THE SETTING

Compression

I have been reading with much interest the arguments put forth by some of your engineering contributors regarding compression. Now it strikes me those engineers who advocate no compression must be men who are running small engines, say from five to 50 horsepower. To my mind the necessity of compression is clear, especially in large engines.

I have had the opportunity of experimenting a little along this line, and by way of proof I tried running a 1000 horsepower cross-compound engine without compression, and I must say it proved to me beyond the shadow of a doubt that compression is essential, if you want a quiet, cool-running engine. This experiment also proved to me that compression is a steam saver. Of course, it is like everything else, you must not have too much or too little, but just the right amount if you want good results.

Does it not stand to reason that if you retain the proper amount of exhaust steam in the cylinder to ease the engine over the center and start it off on the return stroke, that it is more economical than using live steam? Besides, the speed of the engine is kept more uniform by the use of compression. I think if those engineers who advocate no compression would do a little experimenting along this line they would soon find out which is the better way.

Take large engines with heavy moving parts; is it not better to bring those parts to rest at the end of each stroke with a little compression than it is to allow them to start off with a thump the instant the live steam strikes the piston?

I am not conceited in regard to my ability as an engineer, but I think if I had some of those fellows who advocate no compression in the engine room with me for a while I would send them away with their minds made up never to run an engine again without compression.

J. T. FRANKLIN.

Alberta, Can.

Which End Does the More Work

In my letter on page 412 of the September 8 number the word "not" was omitted after the word "cylinder," fifth line, first paragraph.

R. MANLY ORR.

Brantford, Ont.

Unscrewing Large Pipe Couplings

To unscrew a large pipe coupling that has been screwed together with a greater force than can be secured to unscrew it, or that has become rusted fast, a good plan is to heat the coupling by building a bed of coals around it, or better still, if it is feasible, turn a jet of steam on it. At the same time try to unscrew, with chain tongs or whatever is at hand. The coupling will heat sooner than the pipe, and will expand away from it.

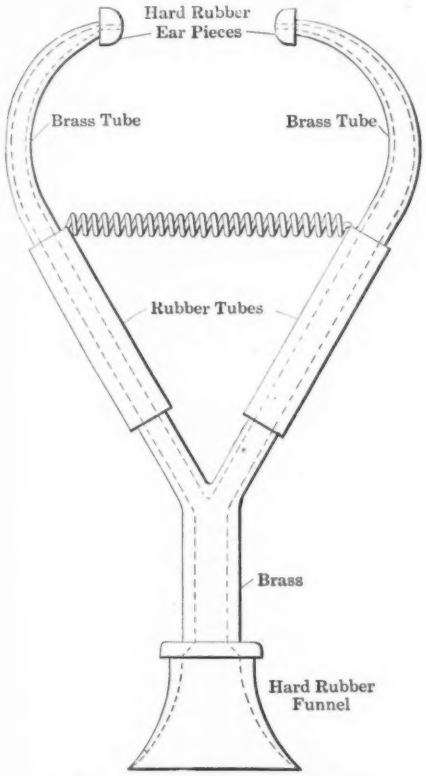
This is the method used by well drillers to unscrew the large pipes used as drill rods in making large wells by the rotary process.

JOHN B. SPERRY.

Aurora, Ill.

Detecting Noises in Engines

For a considerable time I have been using an ordinary physician's stethoscope to locate unusual noises in multi-cylinder,



FOR DETECTING NOISES IN ENGINES

marine and automobile gas engines. This instrument, shown in the illustration, is very effective for this purpose.

ROBERT MILLER.

New York City.

High Water Glasses

We are running a battery of several vertical boilers on which the water glasses are necessarily placed about 20 feet above the ground. This made it very difficult for the firemen to see the hight of water in the glasses, and various means were considered and tried for overcoming the difficulties. We tried to have "the old man" get the patented arrangement where the water glass is brought down to some convenient point on the furnace front, but he said we would have to get along with something else until the money market picked up. We tried various colored backgrounds, such as tin, the horizontal cross-section being a V, the two legs of which came about opposite to or in line with the water glass, and painted them every color from white to green, but without any very marked improvement.

After trying a number of different ways, someone thought of the scheme which is used in magnifying thermometers and we painted a strip of tin white and ran a colored line down the middle, the breadth of the line being about one-third the bore of the water glass. By putting wings or projections on this tin, two at the top and two at the bottom we were able to fasten it permanently to the water column, by bending these projecting strips around the column, bringing the painted strip of tin practically against the water glass with the colored line exactly opposite the bore of the glass.

Any scheme for fastening may be used, but it is preferable to fasten the strip to the column rather than to the glass itself, since by so doing it is independent of the glass and not affected by changing or cleaning it. From a distance the colored line is practically invisible above the water level, but below the water level the water acts as a magnifying glass and the colored line fills out to the entire outer diameter of the glass. After trials with different colors we found a white background with a black line preferable to vermilion, which was the second best considering both daylight and hooded electric lights. The hight of water can be quickly seen by a mere glance without any close examination whatever and the scheme is especially valuable in telling whether the glass is entirely full or entirely empty, where the high- and low-water alarms both operate the same whistle.

E. W. FISKE.

Mexico City, Mex.

Tramming an Engine

When putting an engine on center or tramming, why not put the tram marks on the engine frame, as shown in Fig. 1?

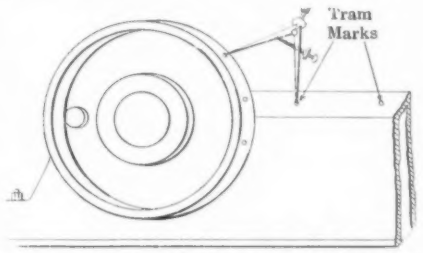


FIG. 1. WHERE TO PLACE THE TRAM MARKS

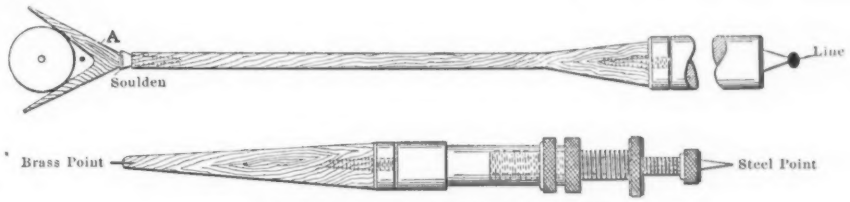


FIG. 2. TOOL FOR LINING UP ENGINE

This would save time, and when another engineer takes charge he will not have to tram all over again.

A tool used in lining up an engine is shown in Fig. 2. It is made of a brass rod and by placing a stick of wood at the other end as shown, it can also be used for truing shaft by putting a piece of tin made and secured to a stick as shown at *A*.

A. L. JOHNSON.

Somers, Mont.

Belt Lacing

Mr. Webster, whose inquiry in the June 9 number is answered by both Mr. Ranney and Mr. Strother in the July 21 number, must be in some confusion as to the best belt lacing, as the testimony of one contradicts that of the other.

My experience of years in a large cotton mill with thousands of feet of belting in sizes from ⅜ inch round to 36 inches double, leads me to say that no laces of any kind should be used; that up to 2 inches single, belt hooks or the clasps with teeth, which are driven through the ends of the belt, are best. They are more quickly applied by the ordinary repair man, hold as well, or better, than any lace, and the belts are easily taken up.

Above 2 inches single, we found by far the most satisfactory way was to make the belts endless by scarfing them and cementing together as the belt manufacturer does.

In this way a great deal is added to the life of the belt and there is no slip or jump when the joint goes round the pulleys.

With regard to Mr. Ranney's statement: "I have taken apart a whang-laced belt

and laced it with wire, as explained, between the ends and the large holes punched for leather, and I have never had the wire-joint fail. It would invariably break where the large holes were punched for the leather lacing," the writer would expect just what Mr. Ranney says happened, because he has deprived the leather left by the holes of the stiffening action of the lace and has also stiffened the belt at the ends by his wire lacing, thus increasing the bending action at the weakest points, viz., the lines of lace holes.

However, it is beyond me to understand how the test applies to the discussion in any way, as all he proves is that with wire lacing and a series of holes back of it on each side, the belt breaks at the holes rather than at the wire lacing, the whang lacing not being considered at all.

As to a governor belt, I should most emphatically not allow anything but an endless belt in this most important place. I suppose the only positive governor drive is gears and shaft, or a sprocket chain, as Mr. Eldredge, of St. Louis, found when he attempted to run alternators in parallel, as per his paper on this subject some little time ago.

HENRY E. FISHER.

Boston, Mass.

The Effect of Compounding

De Witt Pourie, on page 153 of the July 28 number, stated, in his opinion, that while compounding an engine may decrease the steam consumption, it does not, to any great extent, increase the maximum indicated horsepower that can be obtained. I have heard statements to this effect several times among various engineers and it appears as though this misconception of the fundamental principles of the compound engine is becoming rather serious.

In the first place what does the maximum horsepower of a steam engine mean? What is the maximum horsepower of a 24x48-inch single-cylinder engine? No one can tell unless he also knows the initial pressure, cutoff, number of revolutions, back pressure and thermal efficiency. It might possibly vary anywhere from 120 horsepower or less to 2060 horsepower or more. It may seem out of all reason to expect to be able ever to get over 2000 horsepower from a 20x48-inch single-cylinder engine, but if the steam pressure were 150 pounds, which is not excessive, and the piston speed were 1000 feet per minute, which is not the highest speed that has been reached by large Corliss horizontal engines, and if steam were taken at full boiler pressure for the full stroke, then:

$$\frac{150^2 \times (24^2 \times 0.7854) \times 1000}{33{,}000} =$$

2060 *horsepower.*

But in spite of this, it would be absurd to call this engine a 2000-horsepower engine, or for any engine builders to claim that it could be run at any such power. The reason for this is found in the fact that the modern steam engine is designed to give the maximum horsepower per pound of steam under practical conditions and not to give the maximum horsepower possible per cubic foot of bulk. Now the effect of compounding, tripling or quadrupling is to increase greatly the horsepower obtained per pound of steam by making a greater number of expansions practical. The effect of increasing the number of expansions is seen in the accompanying chart, which shows the number of foot-pounds of energy obtainable from one pound of steam at 150 pounds boiler pressure when expanded a various number of times up to twenty.

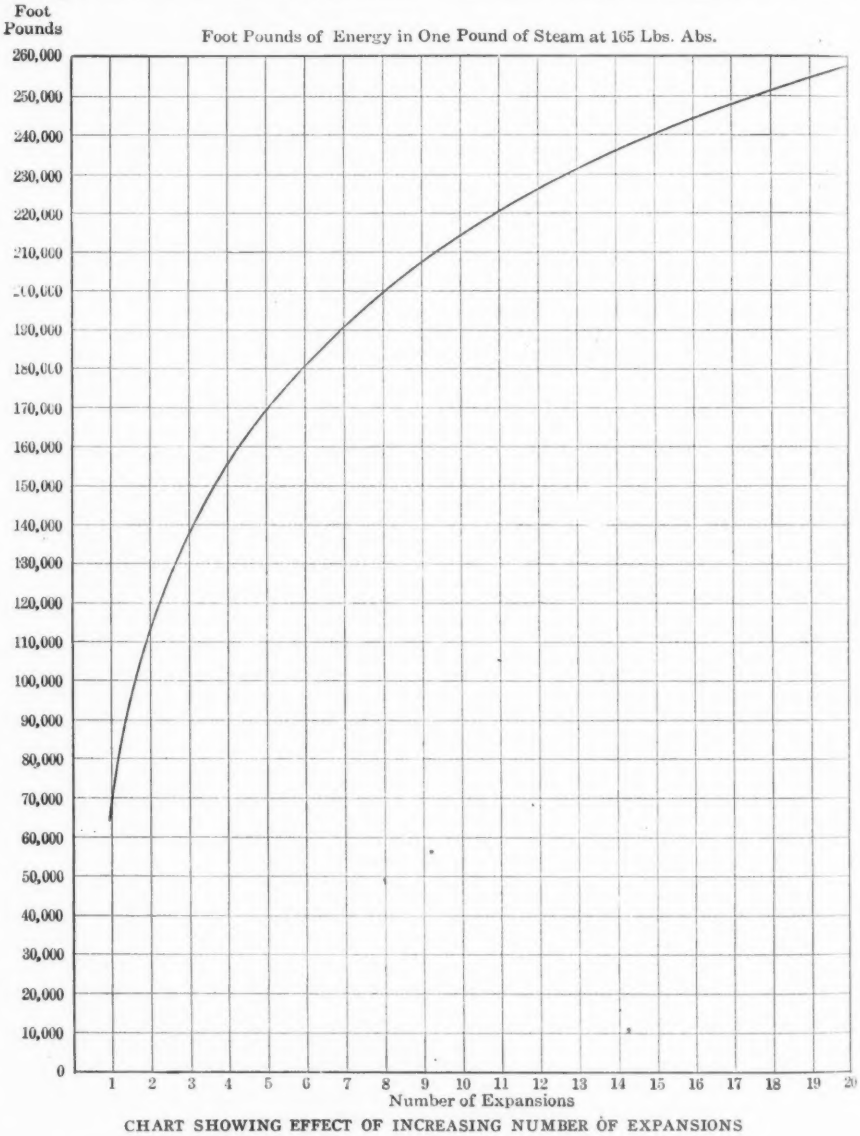


CHART SHOWING EFFECT OF INCREASING NUMBER OF EXPANSIONS

This shows the increasing economy due to increasing the number of expansions, and a much larger number of expansions would be used in the engines of today were it not due to various losses, which become relatively great as the number of expansions increases and thus offset the possible gain. However, recent improvements, such as the steam turbine for instance, have enabled the expansion to be carried to a far greater degree than is considered practical in reciprocating steam engines.

I would also point out to De Witt Pourie that using a damaged compound as a simple engine in the way spoken of is nothing unusual and that probably most engineers have at some time or other had to do a similar thing to help out in a time of trouble and tribulation, but the fact that most compound engines in case of need can be induced to develop the same brake horsepower with one cylinder out of commission does not in any way intimate that the compound engine is not greatly superior to the simple engine. Remember, the average compound engine is probably getting twice the horsepower out of a pound of steam that the average simple engine is, and if it is compared with some of the simple throttling engines I have seen, it is giving three times as much power, possibly four.

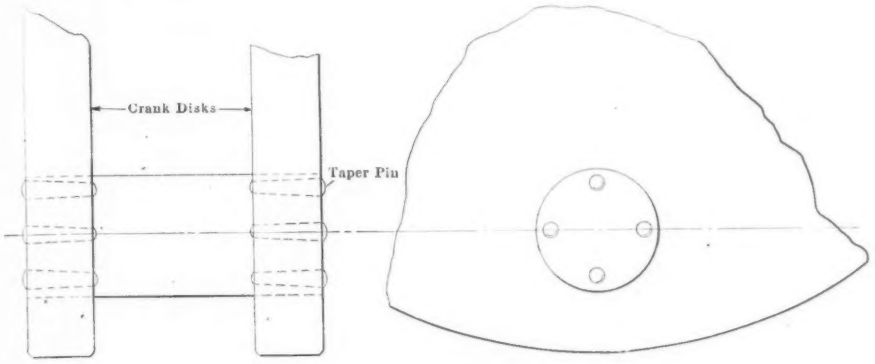
GEORGE P. PEARCE.

Exeter, N. H.

Tightening a Loose Crank Pin

We had an experience the other day with a crank pin that may be of interest. The engine was a 40-horsepower, having a double crank disk, and had been giving trouble. This particular time the crank pin became loose and, of course, began pounding.

As this was not the first time a similar occurrence had taken place, and as riveting the ends did no good, we decided to kill or cure the trouble this time. In each end of the crank pin we drilled and reamed four ⅜-inch taper holes in which we drove with a sledge four taper pins, as shown in the accompanying sketch.



USING TAPER PINS TO TIGHTEN A CRANK PIN

This forced the pin metal hard upon the disk and now it is as tight as any means could produce. We allowed ⅜ of an inch on the pins for driving in, but could only drive them ¼ inch before they were tight.

WILLIAM LONGSTREET.

Wilkinsburg, Penn.

Vacuum Gages and Altitude

The somewhat general misunderstanding of the effect of altitude on steam and vacuum gages is well illustrated by the following bit of correspondence between two engineers.

"I note you say that you get 19 inches of vacuum when everything is tight and the condenser tubes newly cleaned. Is your vacuum gage regulated so that at your elevation of 7600 feet it will register zero when there is no vacuum on the exhaust line? In other words, a gage that would register zero at sea level would show about 7½ inches vacuum at your elevation, and when you get a reading of 19 inches you have really pulled something entirely different."

The misconception here is in the statement that at the high altitude the gage would show a 7½-inch vacuum. The U-tube of the gage, whether steam or vacuum, registers the difference between the pressure inside the tube and that outside, and a zero reading merely means that these pressures are equal, but shows nothing whatever as to what either pressure may be. Then when the gage reads 19 inches as in the case above quoted, it merely means that the pressure inside the tube is 19 inches less than that outside. But at the elevation given the outside or atmospheric pressure is about 22½ inches, showing that with his 19-inch reading, he is within 3½ inches of a perfect vacuum, and that his condenser is doing as well as one at sea level with the gage showing 26½ inches.

The atmospheric pressure for any given altitude may be found by reference to any of the pocket textbooks, but for ordinary altitudes it may be approximated by subtracting 1 inch from the reading at sea level (30 inches) for each 1/1000 foot elevation. Thus, at 6000 feet this rule gives 24 inches, which is only between 1/10 and 2/10 inch too high, or much closer than any engineer reads his gage in practice.

Again, if it is known that certain familiar conditions should give a gage a reading of 25 inches at sea level, we may know without reference to any tables that something is wrong if the gage does not read 17 inches at an elevation of 8000 feet. This rule also applies to steam pressures and in making calculations of boiler tests, or temperatures of pressure steam for any industrial purpose as exact heating, the heat quantities per steam tables should not be taken from gage pressures, but from gage pressure minus the difference in atmospheric pressure between that elevation and sea level. In other words, reduce everything to absolute pressure.

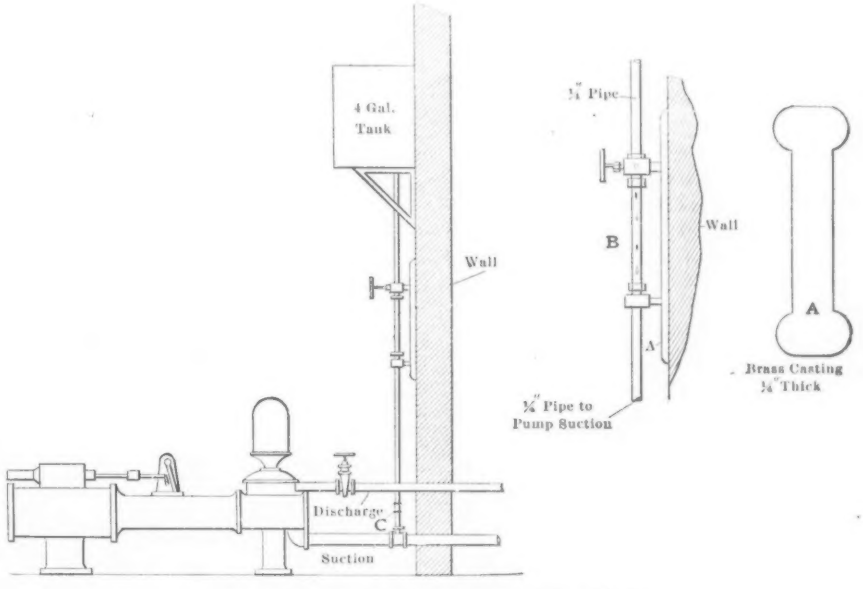
A good example is the duty to be expected of a feed-water heater. At an elevation where the atmospheric pressure is 10 pounds per square inch, the temperature of boiling water is, roughly, 193 degrees Fahrenheit, or 19 degrees less than at sea level, and the engineer should not expect his feed water to be as hot, by about 19 degrees, as he is accustomed to seeing it. A rough rule of thumb covering this, is: Deduct ½ pound from 14.7 for each 1000 feet elevation and the result will be atmospheric pressure in pounds per square inch, and will ordinarily be within the accuracy of the average gage.

E. W. FISKE.

Mexico City, Mex.

Feeding Compound into Boilers

I have read a few letters in POWER AND THE ENGINEER lately on different methods of feeding compound into boilers, all of which are very good and practical, but as I have not seen any arrangement like mine, I thought I would tell how I have been feeding it for many years.



FOR FEEDING COMPOUND INTO THE BOILER

As we had discarded an old lubricator on one of the engines and replaced it with an oil pump, I took it apart and after making a pattern *A*, had a brass casting made to which was fastened the top and bottom connections of the right feed, as shown at *B*. This was screwed to a board firmly fastened to the brick wall. A ¼-inch brass pipe connected the upper end

to a 4-gallon tank on a shelf overhead, which holds the compound. The lower end was connected to the suction end of the boiler feed pump, as shown. A check valve was placed in this pipe at *C*.

The amount of compound used can be regulated by the handwheel to any required number of drops per minute, and as the feed pump is in operation all day it delivers the compound at a uniform rate.

F. P. KINDER.

Saxonville, Mass.

Copper for Bearings

On page 318, August 25 issue of POWER AND THE ENGINEER, George W. Havlin has an article on using copper for bearings, which for some reason people will not try.

In its natural state it is too soft, and for bearings it should be hardened so that it will work about like cast iron. Mr. Havlin uses sheet copper, which approaches the condition, but would not do for heavy bearings. Copper can be made as hard as desired for castings, and there have been two different hardened coppers put on the market for bearings, but sufficient customers could not be found to make it a commercial success.

Wrist-pin brasses on a 5-inch pin made of the ordinary composition were cut in ten years, and were replaced with hardened copper, and while the engine had nearly double the load during the latter time, the copper was in use nineteen years with but little wear, and was taken out because a crack appeared in one of them and the engineer running at the time did not know but that they were of ordinary composition.

A sheet of hardened copper ½ inch thick was prepared to show its shot-resisting qualities and a Mauser rifle that would send a shot through a ½-inch steel boiler plate would only penetrate the copper ⅛ inch.

W. E. CRANE.

Waterbury, Conn.

Engine Diagrams

Realizing the interest most engineers take in freak diagrams, their cause, cure, etc., and for the benefit of those who may be running Russell engines, I will give some of my experiences with this style of engine and one particular repair job.

The accompanying diagrams were taken from a 13 and 20½ by 20 tandem-compound engine, that has been running about six years at 220 revolutions per minute, with an irregular electrical load of from 600 to 800 amperes. The engine is equipped with the Rites governor. The average boiler pressure is 150 pounds and the high-pressure diagram, No. 1, was taken with an 80 spring; the low-pressure diagram, No. 2, was taken with a 40 spring.

On account of a worn valve stem, which made it rather difficult to keep packing in the high-pressure stuffing box for any length of time, it was replaced by a new one. This type of engine has the well-known double-parted Giddings valve, Fig. 6, which in this case was the cause of most of our trouble, the engine being taken down four times before the real cause was learned.

As the high-pressure valve was slightly

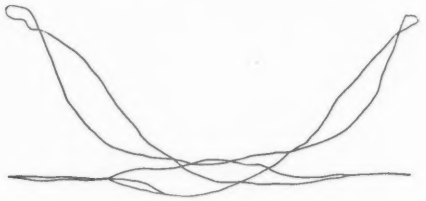


FIG. 1

cut at one end, we decided to take a light cut off its face. Then using the valve as a templet, the seats were scraped to as good a bearing as possible. The four lugs on the inside of the valve cover were reinforced by brass strips to hold the valve to its seat, or to replace the amount planed and scraped from both valve and

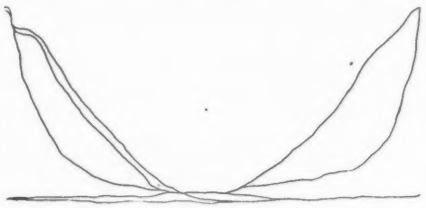


FIG. 4

seat. After connecting up, the engine ran for 35 minutes fairly well, except that the wristpin bearing began to heat up.

The engine was then stopped, the wristpin bearings taken out, filed and scraped to a good fit; but upon running again the same results were obtained and diagrams Nos. 1, 2 and 3 were taken.

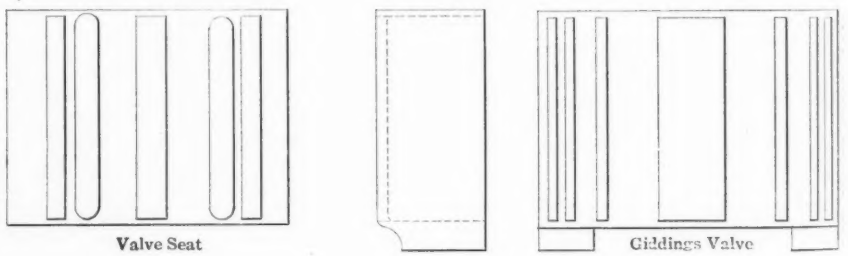


FIG. 6

Upon opening the indicator valves, the discharge from each end sounded equal, but the low-pressure was too harsh, and it was necessary to use a 40 spring to get a diagram in proportion to the high-pressure, or one that was not distorted.

It was very evident the receiver pressure was too high. No. 1 diagram showed a leak in the high-pressure valve, causing the low-pressure cylinder to do more than its share of work. This unequal distribution of steam caused a back pressure on the high-pressure piston which caused the wristpin to heat up.

We went after it again. To verify our former work the valve seats were examined with a straight edge and found straight and true. The valve was leaded again and the contact was good the entire surface, but by this time the valve was so cold as to be handled with the bare hands.

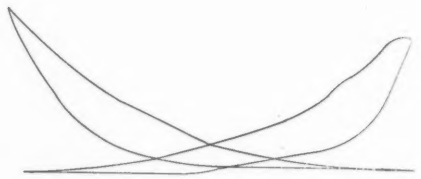


FIG. 2

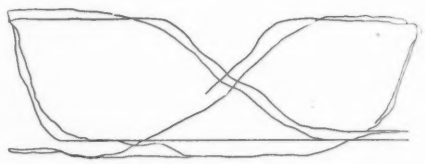


FIG. 3

After studying the construction of the valve, which is a hollow box-like affair with about ½ inch or more of metal on its outside, I came to the conclusion that the heat of the steam caused it to expand more on the outside than it did on the edge or inside, thus preventing a good contact on the central ribs at the exhaust ports and permitting steam to blow past the high-pressure valve.

The valve was then placed in position

FIG. 5

and a jet of steam turned into the valve chamber, until the valve was so hot we had to use a bunch of waste in each hand to lift it out. After leading the valve with red lead and again placing it in position, we found our diagnosis to be correct.

After a few hours' more scraping—and some swearing—the valve and stem were replaced and diagrams Nos. 4 and 5 were taken with an 80 and 40 spring as before;

these show a better condition in both cylinders, and as nearly right as I could expect from an engine that had done so much work.

The steam blowing past the high-pressure valve caused a slight chatter when the engine was running light, but as this is a peculiarity of this valve if there is some condensation, I did not consider it a serious defect, and would expect it to disappear after a few hours' run.

No. 5 diagram was taken with a load before any changes were made in the valve, or soon after No. 1.

W. D. RANNEY.

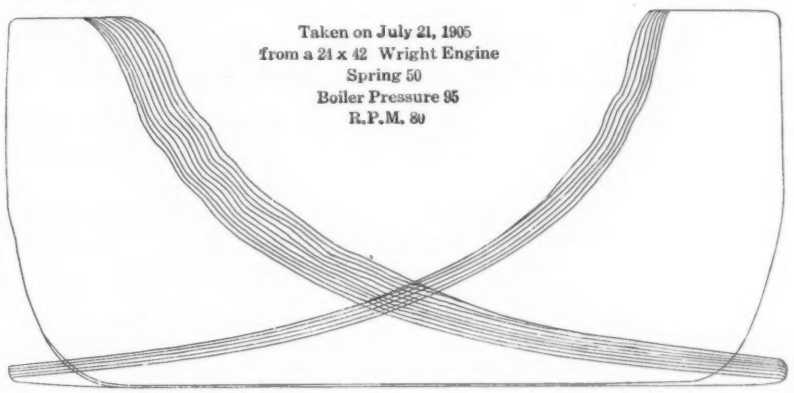
Columbus, Ohio.

Setting the Valves of the Wright and Reynolds Engines

In the July 7 issue, Mr. Collins has an article on "Setting the Valves of the Wright Steam Engine," in which there is much with which I disagree. Mr. Collins says: "These engines were made and put in operation before the niceties of engine design were thought of," but Mr. Collins' illustrations of the lifting yokes *I*, in Figs. 5 to 13, inclusive, are extremely schoolboyish and the construction shown does not represent Mr. Wright's design at all. In fact, the valve gear, and hence the engine, would not operate as Mr. Collins illustrates the lifting yokes *I*, and it would be no more labor to sketch them correctly than to sketch them as Mr. Collins has done. I think it important that the mechanism of an article of which it is the subject should be illustrated, if illustrated at all, so as to show the salient points in its operation, and this Mr. Collins' drawings fail to do in the case of the lifting yokes.

As a general proposition, there is no difference in principle in the movement of any release cutoff-valve gear from the Corliss valve gear, and this is particularly true of the Wright engine, but Mr. Collins calls particular attention to the fact that "the movement of the eccentric is enough to give a travel twice the width of the port and lap of the valve, but the valves themselves travel only far enough to overcome the lap and port opening," as though this were a peculiarity of the Wright engine and not inherent in all four-valve gears operated by a single eccentric through the medium of a wrist-plate. Farther on, Mr. Collins says that on account of Mr. Wright's crude design the distance between the edge of the valve and the end of the lifting toe in the yoke cannot be adjusted, and therefore "more care must be taken in each step toward setting the valves."

In reference to this statement it is interesting to note that the arm on the valve rod of a Corliss engine cannot be adjusted, which adjustment would correspond identically with adjusting the length of the valve rod on a Wright engine. The fact is the position of the arm, relatively to the opening edge of the valve, on Corliss valve stems is very carefully determined in the shops of the various makers and keyed on the stem so no change can be made afterward to meet the whimsical notions of "near experts," and the length of the Wright valve stem was likewise determined and made nonadjustable for the same reason.



DIAGRAMS FROM A 24X42-INCH WRIGHT ENGINE

Mr. Collins, at the end of his article, says: "To get earlier cutoff the change can be made on the rod *S*, Figs. 11, 12 and 13, but if earlier cutoff is secured in this way there will be less lead. To obtain a later cutoff in this way will give more lead." As to the wisdom of changing the length of the rod *S* to obtain earlier or later cutoff I would say, "Think it over," but it would not affect the lead practically, as the diagrams herewith show. These diagrams were taken by me from a 24x42-inch Wright engine at a rolling mill in New York City, the valve gear being identically the same as Mr. Collins' article treats of. The pencil was allowed to trace the paper for several alternate strokes to show the variation of load and the action of the governor and the steam on both sides of the piston under varying conditions. The action of the governor when the balls revolve in varying horizontal planes varies the cutoff in identically the same way as varying the length of the rod *S* would if the governor balls revolved in a single horizontal plane, but the diagram does not show any change of lead.

In Mr. Collins' article in the August 11 issue, on the Reynolds long-range cutoff, he says "the first engine of this design built by Mr. Reynolds" was "for the World's Fair at Chicago," which was, of course, in the year 1893. Farther on he says, "When the steam valve is lapped the proper amount the dashpot plunger is down at the bottom of its travel and the cranks *E* and *E'* are at the lowest positions of their travel. The eccentric must come over to its extreme position in order that the valve may be picked up. Owing to the dashpot and method of cutoff on a Corliss engine this arrangement can be applied, but is not applicable to any other type of valve." This statement is at variance with the facts, as such four-valve release cutoff engines as the C. H. Brown, the Wheelock, the Green and many others are built with long-range cutoffs and the first one Mr. Wright built was in 1884 or 1885, some eight or nine years before the World's Fair at Chicago; this engine is running yet in a mill at Lowell, Mass. The valve gear is the same design that Mr. Collins discusses in the July 7 article.

R. A. NIVEN.

Brooklyn, N. Y.

In reply to Mr. Niven's letter, I beg to say that the assertion that "these engines were made and put in operation before the niceties of engine design were thought of," was intended to convey the fact that many refinements in general engine design have been made since the time of Mr. Wright's successes in that field; the specific reason for this statement is contained in the same paragraph. As for the assertion that the illustrations for the lifting yokes are "schoolboyish," the writer has only to say that they were based on Mr. Wright's old shop drawings and were approved by J. K. Wright. The object was merely to indicate the positions of the valves and parts during a revolution, not to show in full all of the details of construction, hence the sketches are partly diagrammatic.

Mr. Niven's assertion that the valve yoke would not operate as illustrated is erroneous, as clearly proved by his other statement that his indicator diagram was taken from an engine having a valve gear identically the same as that which I described. Moreover, if that were true, no grab hook on a Corliss gear would operate, for the very reason that he presents, namely, that "as a general proposition, there is no difference in principle in the movement of any release cutoff-valve gear." The assertion that the cutoff is not varied through the medium of the splined rod *S*, Figs. 11, 12 and 13 of the article referred to, is also erroneous.

I have always believed that Mr. Wright

was one of the best engine designers who lived, a pioneer in engine design and manufacture, and nowhere in the article referred to are there such words as "on account of Mr. Wright's crude design," nor was there any intention to convey the idea that the general design was crude for its day.

HUBERT E. COLLINS.

New York City.

Combustion or Total Heat Formulas

In the August 11 issue, there appeared an article headed as above, in which the relative values of the various formulas was taken up. The author seems inclined to take up for Goutal's formula, based on the proximate analysis, and at the same time casts a certain shadow of unreliability upon the others. Those formulas which correct for the moisture in the coal or any other conditions cannot be compared with formulas such as Mahler's, Dulong's or Goutal's, because in these no such correction is made. For this reason, we would not expect that the heating value would be the same as that calculated by one of the other formulas. The whole question resolves itself into a comparison of such formulas based on ultimate analysis, such as Dulong's, and those based on the proximate analysis, such as Goutal's.

I have, in the last few months, attempted to get some definite relation of the heating value to the fixed carbon in the combustible, but was able to do so only in a general way. I used the analysis of the coals used at the coal-testing plant of the United States Geological Survey at St. Louis, and included about 70 analyses of coals ranging from anthracite to lignites. I plotted a curve, but it was very irregular. There were two samples whose fixed carbon was 52 per cent., one of which had a heating value of 13,430 B.t.u. per pound of combustible, while the other had 14,860 B.t.u., a difference of 1430 B.t.u., or about 10 per cent. It is almost possible to guess that close. I might say here that all my figures are based on combustible free from ash. The above coal was of the lignite class, however. I have plotted a curve representing Mahler's tests and also the actual average of the St. Louis tests, and with it a curve representing Goutal's formula. Between 60 and 70 per cent. fixed carbon in combustible, the maximum variation of the three is less than 400 B.t.u. per pound, but under 60 per cent. the variation is very large, and over 70 per cent. there is also some considerable variation, but not as large as with the low ones.

I also took three coals, one having 60.69 per cent., another 59.60 per cent., and a third 60.95 per cent. of fixed carbon and solved for the factor M in Goutal's formula. The following are the values I got:

Per Cent. Fixed Carbon.	M =
59.60 per cent.	14,580 B.t.u.
60.69 per cent.	16,000 B.t.u.
60.95 per cent.	16,530 B.t.u.

Here, there is a variation of nearly 2000 B.t.u. in the value of M, with only a difference of 1.35 per cent. in the fixd carbon. I have figured the factor M for the entire seventy coals, but have not yet plotted the same. While there is a tendency for the heating value to increase with the fixed carbon, I do not think that it is possible to lay down any reasonably reliable formula for calculating the same from the proximate analysis.

As for Dulong's formula, I have taken some thirty-five analyses of coals and compared their actual heating value as determined with a bomb calorimeter, with that as figured from Dulong's formula. These figures are also taken from the St. Louis tests and I have the greatest confidence in the accuracy. The average difference between the calorimeter test and Dulong's result was 151 B.t.u., or about 1 per cent. The maximum was 588 B.t.u., one coal testing 15,848 B.t.u. per pound of combustible, or about 3.75 per cent. The minimum was 9 B.t.u. on 15,155, or about 0.06 per cent. These thirty-five analyses include coals with fixed carbon all the way from 43.80 per cent. up to 82.73 per cent. This confirms the results obtained by several other experimenters as to the usefulness of Dulong's formula.

If the author of the previous article had taken ten or twenty different coals he might have perceived the advantage of using Dulong's formula.

It is also worthy to note that the fixed carbon may be varied considerably in the hands of different chemists or even in the hands of the same chemist. I have had variations myself of about 1 per cent. In order to get the same results the conditions of heating, etc., must be the same. It is very much to be regretted that the fixed carbon cannot be used as a basis for calculating the heating value, as most any person can make a proximate analysis of a coal, while the ultimate analysis is difficult even for the expert chemist, owing to the difficulty of completely burning the volatile gases.

There is now on the market a calorimeter of a comparatively low price which was designed by Professor Parr, of the University of Illinois, which, I believe, will give good results in the hands of the engineer. I have had no personal experience with this instrument, but from its description and method of manipulation I would consider it no more trouble to make a calorimeter test than a proximate analysis. The result, I am sure, would be as accurate as that figured from the ultimate analysis, and the cost of the calorimeter is only about twice as much as a platinum crucible suitable for proximate analysis. There is comparatively little known yet about the relation of elementary composition of coal in relation to its calorific value or chemical constitution in spite of the amount of work done along these lines. Thus the heating value of twenty-nine out of the thirty-five samples, which I used above, was higher than the heating value of the elements themselves.

JAMES E. STEELY.

Covington, Va.

Lengthened the Knock-off Sticks

I have charge of a Nightingale Corliss engine that was operated throttling for years and if the pressure was above 60 pounds, off she went. I found, by making the knock-off sticks as long as they would work and setting the valves over, that the engine would regulate at any speed up to 100 revolutions per minute.

I think the safety stop on the wedge on the governor rod is good. I would like to have Mr. Waldron inform us how he works the sliding plate; does he cut an oblong hole in the rod?

F. M. ARNOLD

Worcester, Mass.

The Most Frequent Cause of Boiler Explosions

In the August 25 number of POWER AND THE ENGINEER, R. Cederblom seems doubtful as to the accuracy of the statement that scale is the most frequent cause of boiler explosions, and he asks why, if this is so, there is such a crusade against lap-riveted boilers. Mr. Cederblom evidently has in mind a meaning of the word "explosion" different from that expressly stated in the article. If he will refer again to the article he will find that I was careful to define "explosion" as the *tearing asunder of any part of a boiler by force of steam pressure.*

The reason for this definition is that any accident coming within it is considered by the Fidelity and Casualty Company an "explosion," the loss from which is covered by its steam-boiler policies. The frequency of explosions, therefore, is measured by the frequency with which these losses occur, and they cover all sorts of explosion, violent and otherwise.

Every year there occur in the United States 1300 to 1400 *serious* boiler accidents, of which 300 to 400 are *violent explosions.* Mr. Cederblom probably had in mind only the latter, and they are rightly responsible for the crusade against lap-riveted boilers.

Oil, as stated by Mr. Cederblom, is a frequent cause of boiler explosions, but statistics show that scale, or a mixture of scale and oil, is by far the most frequent cause. As these statistics are reproduced in part in another article on the subject in

this number of POWER AND THE ENGINEER, Mr. Cederblom may judge for himself.

WILLIAM H. BOEHM.

New York City.

Engineering Blunders

One night a foreman and engineer started in to repair the engine in a button shop in Buffalo, N. Y. They did not know how or where to begin. They decided first to take off the cylinder head and fix the rings. In trying to take out the ring to peen it they broke out a piece about 4 inches long and then concluded to stop and put it back again, as they did not think a little thing like that made any difference.

The foreman told the engineer to say nothing of what had happened. The next week the coal bill ran to nearly twice the amount it had been and the power was bad. The head man wanted to know the reason why his engine used up so much more steam than formerly. The engineer was afraid he would lose his job if he told the truth and so kept quiet. They finally sent to the shop and I went over and found the broken ring. We made two new rings and put them in, and the next week the coal bill was much lower and there was plenty of steam.

This engineer was not licensed, but he received good pay for what he knew—$1.35 per day for 11 hours' work. I have read of a number of cases where the blame was laid to the inspector, but in nine cases out of ten it lies with engineers wholly unfit to run a plant.

I went to a place not long ago where they had the fire pulled and could not get water in the boiler, but after opening the blowoff for ten minutes the water showed in the top of the glass. That engineer had the boiler so full of water that the injector could not get steam.

What we need most is an inspector of engineers and firemen. Where an engineer cannot tell what is the matter with his plant, he should give up his license and get a job with some of the "has-beens."

S. J. KELLEY.

Orange, N. J.

Poor Arrangement of Horizontal Tubular Boilers

The front elevation of two horizontal return-tubular boilers is shown in Fig. 1.

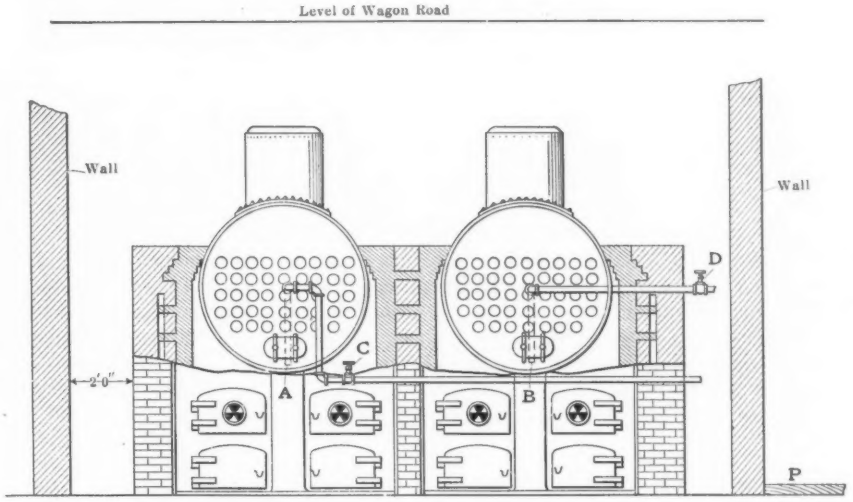


FIG. 1. FRONT ELEVATION OF BOILERS

Two pipes *A* and *B* were placed in the boilers to blow out the mud, each pipe having a valve *C* and *D*. By opening these valves three or four times a day we had no more trouble with the sheets bagging.

I think a much better arrangement for these boilers could have been made which would have been more convenient for all concerned as shown in Fig. 2, which is a plan view of the boilers with the furnace doors at *A* and *B*. Coal was used for fuel and was unloaded from wagons onto the platform *P*, Figs. 1 and 2, and was then wheeled by the fireman through the door *E*, and dumped in front of the boilers.

The road passed above the level of the boilers as shown in Fig. 1. This was a hoisting plant and the work was so arranged that the engineer, who was stationed at *F*, had to watch the boilers part of the time, which necessitated him going around his engine and over to the door *G*.

The space between the boiler setting and the building walls at the rear was about 2 feet, as shown, and all soot and ashes removed from behind the bridge-wall had to be taken out in small cans or boxes. If the boilers had been set with the furnace doors at *H H*, Fig. 2, and a coal bin installed as shown, the fireman would not have had to handle the coal twice. It would also have saved the engineer several unnecessary steps; besides, the trouble caused by the boilers settling would have been eliminated.

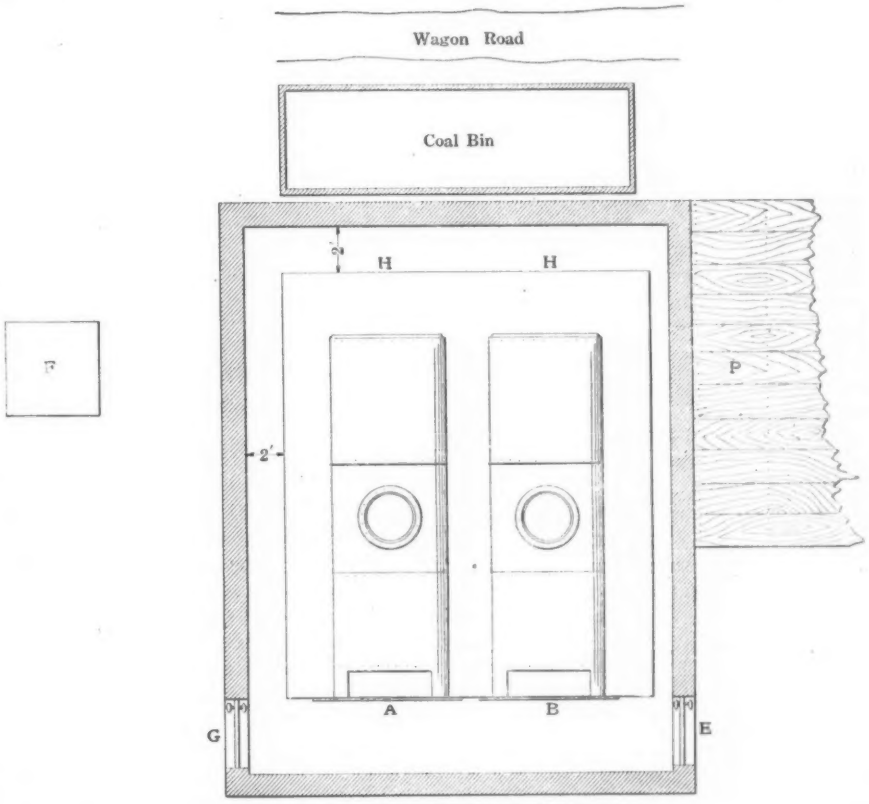


FIG. 2. PLAN VIEW OF SETTING RECOMMENDED

These boilers were set with the front ends resting on filled ground which allowed them to settle about 4 inches lower than the rear end. The water used at this plant deposited a great deal of mud in the boilers which settled on the front sheets, causing them to bag.

EARL E. WEBSTER.

Prescott, Ariz.

Breakdowns of Power Plant Machinery

Taken from the Annual Report of Michael Longridge, Inspector for the British Engine, Boiler and Electrical Insurance Company

The annual reports of Michael Longridge, inspector for the British Engine, Boiler and Electrical Insurance Company, are always interesting and valuable, and the current report (for 1907) fully sustains the reputation for these characteristics previously established.

Steam Engines

Mr. Longridge refers particularly this year to sixteen cases of steam-engine accidents, some of which are of the everyday class and some unusual in character. There are two cases of serious damage to engines due to the flooding of the condenser. In the North of England, says *Engineering*, jet condensers are almost universal, and naturally, if from any reason the air pump stops or slows too much, and the vacuum is not destroyed, the injection water rushes in and floods the condenser. There is then great danger of the water traveling up the exhaust pipe, getting into the low-pressure cylinder, and, if the engine has not come to rest, on the return of the piston something must go. In one case cited, the slackening of a set screw caused the governor to lose control, and the engine began to race. The engineer ran to the stop valve and shut it down, forgetting all about the vacuum in the excitement of the moment. No doubt his idea was to give the engine steam again before the machinery was quite stopped, but anyhow, the injection water was drawn into the cylinder, and a broken bedplate was the result. If an automatic knock-off gear and vacuum breaker had been previously fitted, as the company had advised, all the trouble would have been avoided. The second case was due to what one may almost call culpable ignorance on the part of the driver. His practice was to shut down a high-speed triple-expansion engine by closing the stop valve first, and then a valve in the exhaust pipe between the low-pressure cylinder and condenser. Naturally, it was a race between him and the water to reach this exhaust valve first, and in time the water won, with the usual results. He ought, of course, to have destroyed the vacuum either by shutting off the injection water, or by shutting off the condenser, or by opening the atmospheric valve before closing the stop valve. The injection water was drawn from a pond more than 15 feet below the cylinders, so that a vacuum of about 13 inches would flood the latter when the air pump slowed down.

Another case of smashed cylinders was due to the fracture of the piston rod of a tandem engine. The rod was 5¾ inches in diameter, and broke without warning at a weld. The weld was made a few years before, when a new end was shut on, on account of a crack in the cotter hole. The metal had united all round the circumference of the rod, but the center had never joined.

The report again instances fractures of rectangular flat-sided steam chests, against which the company has been fighting for years. Such chests pant under fluctuations of pressure, develop cracks at the corners, and often end their career by having a piece blown out of them. A Corliss cylinder is mentioned which had to be replaced owing to cracks developing in the high-pressure steam chest, which formed one side of the jacket in the usual way.

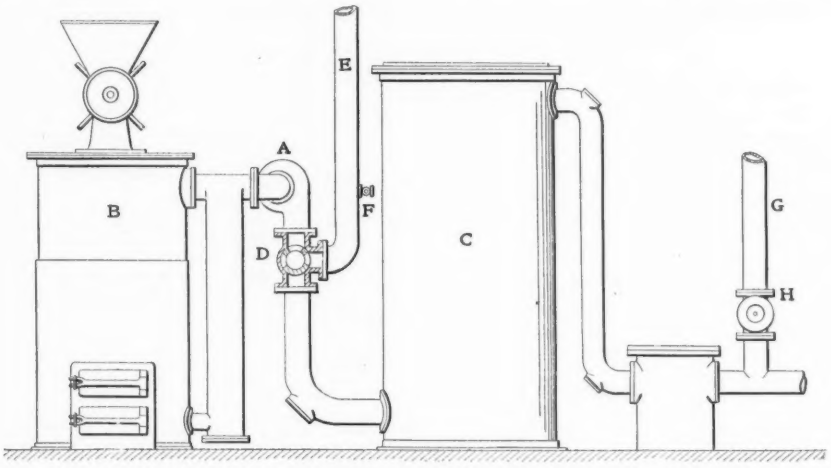


FIG. 1. GENERAL ARRANGEMENT OF SUCTION GAS PRODUCER PLANT

Gas Engines

Of the thirteen gas-engine breakdowns specially mentioned, five were caused by the breakage of bolts in connecting rods. To these may be added one accident caused by a nut coming off one of the big end bolts. All the bolts seem to have broken through the screw thread next the shank, even when the center part of the bolts was reduced in diameter. The only load that comes on cap bolts of gas engines is the inertia stress at the commencement of the suction stroke. The values of this in bolts that broke amounted to 3070 pounds and 2050 pounds per square inch in the two cases of ½-inch bolts, 5030 pounds for a 1¼-inch bolt, and 2220 pounds for a 1½-inch bolt, the stress in all cases being computed on the sectional area at the bottom of the thread. The 1½-inch bolts were said to have been made of vanadium steel. They stood up for 103½ million revolutions, the 1¼-inch bolts lasting for 33,100,000 revolutions.

An ill-fitting flywheel key in one of the flywheels of a 10x18-inch gas engine resulted in the bursting of the flywheel boss and wreckage of the wheel. The key was apparently originally fitted tightly on the sides of the shaft keyway, and less hard on the top. It, of course, got loose, and the rocking of the wheel split the boss from the corner of the keyway. In this connection Mr. Longridge points out the practical impossibility of fitting a key both on the sides and the top. Although what is considered a standard textbook on machine design states that sunk keys "should fit at the sides even more accurately than on the top and bottom," every millwright knows that to try to do this is absurd. With a properly proportioned key the sides may, and should, be made a free fit in the keyway, so that the whole of the tightness is on the top and bottom. The fitter then knows what he is doing, and that when the key feels tight it is properly home. Mr. Longridge recommends the hubs of gas-engine flywheels being split, bored a shade small for the shaft, and secured by tightening up the hub by two or four bolts. The hub would be wedged open while being got into place on the shaft. With this method it is advisable to swell the shaft where gripped, so that the edges of the hub may not indent the skin and start a crack.

Explosion in a Base Frame

One case of gas-engine wreckage was very similar to an accident which occurred last year in Newark, N. J. A horizontal engine seven years old ran on illuminating gas from a city main. The cylinder

was 8 inches in diameter by 16 inches stroke, and the speed 185 revolutions per minute. The engine, after running three hours on the day of the accident, was stopped for about an hour. On starting it again a violent explosion occurred, shattering the frame and tearing the pieces away from the holding-down bolts and cylinder. The pieces were blown about the engine room, and the cylinder, crank shaft, and flywheel were displaced.

The explosion was caused by the ignition of a mixture of gas and air inside the bed frame through which the air for the cylinder charge was drawn. As usual in these cases, the presence of the explosive mixture inside the frame was not accounted for. It was suggested that the engine had perhaps stopped with the crank in such a position that the gas and air valves were open, and that during the stoppage someone walking past the engine had inadvertently opened the stop cock on the gas-supply pipe, and thus allowed the gas to escape into the cylinder and through the open air valve into the frame. But is it really necessary to make these assumptions? Would not the same effect be produced if the attendant, after opening the gas cock to start the engine, took rather more time than usual in pulling round the flywheel to make the charging stroke? In such a case it is quite possible that with gas under pressure a volume greater than the piston displacement would pass the gas cock during the suction stroke, and that the surplus would flow through the open air valve into the frame. Having once filled the supply pipe and frame with an explosive mixture, an explosion almost necessarily follows.

ELECTRICAL APPARATUS.

Description of Part Which Is Believed to Have Failed First.	Dynamos.		Motors.	
	1906.	1907.	1906.	1907.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Armatures and rotors	50	35	44	38
Magnet coils and stators	11	7	14	14
Commutators and brush gear	20	34	28	30
Miscellaneous	19	24	14	18
Total	100	100	100	100

	Per Cent. 1907.	Per Cent. 1906.
Resistance coils	48	60
Contacts and switch arms	10	8
Automatic apparatus	17	13
Miscellaneous	25	19
Total	100	100

The causes of these breakdowns were probably as follows:

	Dynamos.		Motors.		Starters.	
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Accidental	15	8	9	4	22	9
Dirt and neglect	14	25	19	28	11	16
Age and deterioration	21	23	25	23	23	27
Bad work or design	23	21	18	18	9	8
Overloading	0	0	2	1	7	5
Unascertained	27	23	27	26	28	35
	100	100	100	100	100	100

Gas-engine Crank Shafts

The breakage of crank shafts, according to the report, were unusually few, and of such that did break, 25 per cent. broke in the crank web, 37 per cent. in the crank pin, and 38 per cent. in the bearing between the crank and flywheel. The one case described was of a crank pin which broke close to the web. There was no junction curve at the point, as there should have been, and the shaft, moreover, was weak. It broke for the first time in 1904, and again in 1905, 1906 and 1907. The second shaft stood for 149 million revolutions, the third for 14,900,000 revolutions, the fourth for 46 million revolutions, and the last for 52 million revolutions. Mr. Longridge gives the following expression for the strength of such shafts:

$$\frac{C^2 (l + d)}{D^3},$$

where

C = Diameter of cylinder;
l = Distance between inside of bearings on each side of crank;
d = Diameter of shaft;
D = Diameter of crank pin.

The value of the expression should be about 12 for engines with two bearings and overhanging flywheels, and about 14 for engines with more than two bearings. The value in the case of the shaft in question was 33.7, showing that the pin, which was 1⅞ inches in diameter, should have been nearly thrice the strength, or 2¾ inches in diameter.

Valves and Valve Gears

Mr. Longridge says that the increase in breakages of valves and valve gears of gas and oil engines demands the serious attention of makers of these engines. If all side shafts were fitted with ring lubricators and levers made of wrought iron or good cast steel, the percentage in the table would be reduced. The reduction in broken cylinders and pistons is encouraging, and marks the progress which is being made. Connecting rods proved less destructive than usual, probably because of improvement in design, particularly as regards strengths of bolts. Breakages of crank shafts were fewer in 1906.

Explosions in Gas Producers

According to the report, these explosions continue to occur, generally through want of understanding on the part of the attendant, but sometimes through faulty arrangements of the apparatus, and the following is cited a fair example of such cases. The plant was a suction gas plant for supplying a horizontal engine, with cylinder 14 inches in diameter by 22 inches stroke, running at 164 revolutions per minute. It consisted of the usual generator, scrubber and expansion box, shown diagrammatically by Fig. 1. The fan A for blowing up the fire at starting was placed between the generator B and the scrubber C, and between it and the scrubber was a three-way cock D, by which the generator B could be put into communication with the chimney E, the scrubber C, or with both simultaneously. The plug of this cock was of the shape shown by Fig. 2, and could be turned into any position. At the bottom of the chimney E was a test cock F. Between the scrubber and the engine there was a second chimney or escape pipe G, with a stop cock H.

The top of the scrubber was blown off when preparing to start the engine. Two accounts of the accident were given to the company's inspector by the attendant, the first a few hours after its occurrence, the second some days later, after he had had time to study the printed instructions issued by the makers of the plant, and to consider how far he had obeyed them. These instructions were:

First, to put the generator in communication with the chimney by setting the three-way cock to the position shown by Fig. 2, and to blow up the fire until the gas would burn freely at the test cock F. Second, when the gas burnt freely at F to put the generator in communication with the scrubber by turning the three-way cock to the position shown by Fig. 3; then to open the cock H and continue blowing to clear the scrubber and expansion box of "foul gas" or air, and fill it with pure gas fit for use in the cylinder of the engine.

Third, to shut the cock *H* and start the engine.

What he actually did, according to his first account was this: He put the generator in connection with the chimney, blew up the fire, opened the stop cock *H*, and lighted the gas at the mouth of the escape pipe *G*. He then "partly closed" the three-way cock *D*, opened the test cock *F* and

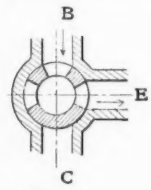


FIG. 2

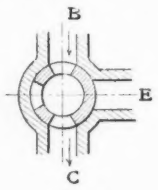


FIG. 3

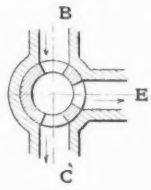


FIG 4

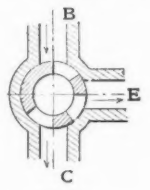


FIG. 5

applied a light to it, when the explosion followed.

In his second account he said that he followed the instructions up to the opening of the stop cock *H*, and then departed from them by lighting the gas at the mouth of the escape pipe *G*, when the gas in the pipe and scrubber exploded.

The first explanation is probably the more correct, and looking at the design of the three-way cock *D*, it is easy to see how the explosion was brought about. The probability is that when he opened the stop cock *H* the scrubber, expansion box, and pipes were full of pure gas left in them when the engine stopped on the previous afternoon, which would not burn until it reached the air at the mouth of the escape pipe. It is also probable that when the fan was started the three-way cock was in the position indicated by Fig. 4, and therefore open to the scrubber as well as to the generator, so that as soon as the stop cock *H* was opened an explosive mixture of air and gas, or foul gas, was forced into the scrubber to take the place of the pure gas burning at the mouth of the escape pipe *G*, and that after being "partly closed" as in Fig. 5 it still allowed communication between the three. Under such circumstances it is evident that a light applied to the test cock *F* would ignite and explode the mixture. If the second explanation be the true one, it is almost necessary to assume that the scrubber and expansion box had in some way become charged with an explosive mixture or with air during the previous night. In the first case an explosion would follow the ignition of the mixture at the mouth of the escape pipe, in the second a moment would arrive when the pure gas, being blown into the scrubber, would be mixed with the air contained therein in such proportions as to explode when brought in contact with a light. Either condition might no doubt have been produced by leaving the stop cock open or the scrubber in communication with the atmosphere through the three-way cock *D* and an insufficient water seal; only in either case one would have expected the expansion box rather than the scrubber to have suffered.

By appropriate manipulation of the cocks *D* and *H* with suitable mixtures of gas and air in the scrubber and expansion box, an inexperienced person, like the attendant in this case, who had only been in charge of the plant three days, could doubtless produce explosions in this or other ways; but the writer is inclined to think that the account first given was substantially correct, and that if the three-way cock had been so constructed that it could not be opened simultaneously to the scrubber and to the atmosphere it would have been much more difficult to have blown the thing up. But even with a properly arranged three-way cock between the generator and the scrubber, there will always be a risk in testing the gas in the escape pipe *G*, unless the scrubber, expansion box, and pipes contain nothing but pure gas when the test is made. If these parts be initially full of air, a time must come when the mixture of this air with the incoming gas becomes explosive. To minimize the risk of explosion by testing at this critical period the test cock *F*, as well as that on the escape pipe G, should be fitted with wire-gauze flame arresters.

Electrical Machinery

The breakdowns of electrical machinery were more numerous and costly than in the previous year. As in 1906, the rate among continuous-current machines was much higher than among alternating, but the average cost of each breakdown was much less, so that the company's policy of charging practically the same rates of premium is justified. A large number of accidents were due to "something" getting into the motor. A piece of cinder, a couple of rats, and some soft soap all figure among causes of trouble; while, of

ANALYTICAL AND COMPARATIVE TABLES.

Steam Engines.

Description of Parts Which Are Believed to Have Given Way First.	24 Years Previous to 1906.	During 1906.	During 1907.
	Per Cent.	Per Cent.	Per Cent.
Valves and valve gear	21	23.3	28
Spur-gearing	14.8	12	10.2
Air-pump motions	10.4	9.9	10.2
Air-pump buckets and valves	7.3	6.9	4
Columns, entablatures, bedplates and pedestals	6.9	8.6	7.7
Cylinders, valve chests and covers	5.2	6.1	7.2
Bolts*	4.7	0.0	0.0
Parallel motions and links	4.5	2.7	5.6
Main shafts	4.4	5.2	2.6
Pistons with their covers, rings and bolts	3.2	3.4	5.6
Governors and governor gear	2.6	1.7	2
Connecting rods, straps and bolts	2.4	5.6	2
Piston-rod crossheads	2.3	2.7	3.6
Flywheels	2	1.7	2
Air pumps and condensers	1.9	2.1	3.1
Piston rods	1.8	2.7	2
Crank pins	1.3	0.4	1.6
Cranks	1.1	0.0	1
Beams and side levers	0.9	0.4	1.6
Gudgeons in beams	0.8	0.8	0.0
Main driving ropes and belts	0.2	1.3	0.0
Total wrecks; causes not ascertained	0.2	2.1	0.0
Second motion shafts	0.1	0.4	0.0
	100	100	100

*These bolts do not include bolts in pistons, air-pump buckets, valves, connecting rods, valve gear and other moving parts, the bolts in these parts being tabulated with the parts to which they properly belong.

Gas and Oil Engines.

Description of Parts Which Are Believed to Have Given Way First.	Average Previous to 1906.	During 1906.	During 1907.
	Per Cent.	Per Cent.	Per Cent.
Valves and valve gear	32.5	28.7	43.3
Cylinders and cylinder ends	16.6	16.7	13.5
Pistons	11.7	6.5	2.7
Connecting rods and their bolts	11.2	12	8.1
Main shafts	5	15.7	4.7
Governors and governor gear	4.4	7.4	7.4
Silencing boxes and exhaust pipes	4.4	2.8	1.4
Flywheels and driving drums	4.3	4.6	4.7
Clutches and couplings	3.5	0.0	0.0
Frames and pedestals	3.8	0.0	4
Bolts*	2.6	0.9	1.4
Total wrecks; cause not ascertained	1	1.9	0.0
Main driving ropes or belts	0.0	1.9	0.0
Miscellaneous	0.0	0.0	5.4
Gas producer plants	0.0	0.9	3.4
	100	100	100

*These do not include bolts in pistons, connecting rods, valve gear and other moving parts, the bolts in these parts being included with the parts themselves.

course, dust, dirt and oil did their share of damage. One motor exploded violently, presumably on account of the firing of gas evolved by the charring of some of the insulating material. What the latter consisted of could not be ascertained, as the motor was of foreign manufacture. In another foreign motor the armature-core plates had no key, but were slipped over the shaft, and were supposed to be held by a ring shrunk on the shaft at each end. Naturally, they shifted, and the conductors, which were led to the slip rings through a sharp-edged unbushed hole in the shaft, were fused. There are other cases of bad or ineffective design, even where the designer was not handicapped by the properties of insulation cotton, copper and of other unmechanical substances.

The rate of breakdown was rather lower among dynamos and rather higher among motors than in 1906. The exact figures are 1 in 18.7 among dynamos and 1 in 7.9 among motors. The corresponding figures for 1906 were 1 in 16 and 1 in 8.2. The proportions in which the various parts of the machines are thought to have caused or initiated the breakdowns of 1907 are specified in one of the accompanying tables, taken from the report. These tables indicate the respective liability of various details of engines, etc., to cause breakdowns.

The causes of these breakdowns may be roughly classified as under:

	Steam Engines. Per cent.	Gas Engines. Per cent.
Accident, or causes unascertained	27	44
Old defects, or deterioration by wear and tear	38	17
Weakness, bad design, workmanship, or material	19	18
Negligence of owners or attendants	16	21
	100	100

In connection with these tables Mr. Longridge makes the following remarks: "The increase in the number of breakdowns of steam engines traceable to failures of valve gears is probably the result of increase in speeds and number of parts. The reduction in the number of breakages from spur gearing is the natural consequence of the substitution of rope and direct driving for the older system of transmission. The steady increase in broken cylinders and pistons is due principally to the use of steam at temperatures and pressures higher than the parts can safely bear."

American Peat Society Convention

The second annual convention of the American Peat Society will be held at the Charles hotel, Toledo, O., October 22, 23 and 24. There will be an interesting program, including papers on "Peat Gasifying," "Peat Coking," "Peat Drying," "Alcohol and Ammonia from Peat," and "The Commercial Outlook of the Peat Industry." Further particulars may be had of Francis J. Bulack, 209 St. Clair building, Toledo, or Julius Bordollo, secretary, Kingsbridge, N. Y.

The Most Frequent Cause of Boiler Explosions

By William H. Boehm*

The article in the August 25 number, page 333, explaining just why scale is the most frequent cause of boiler explosions, has attracted considerable attention, and has been the occasion of there having been sent to us numerous letters and pamphlets, all confirmatory of our statements as to the danger of scale formation.

One of our correspondents expressed to us a mass of scale weighing no less than six pounds and concerning which he writes:

"Your article showing why scale is the most frequent cause of boiler explosions is particularly interesting to us, as we have just sustained a loss of $450 from this source. For a number of years we have used water from a small brook near our factory, and did not know that it contained scale-forming matter until several days ago, when our boiler bagged and ruptured. The cause of the accident was scale, a piece of which we are having sent to you."

It is hard to believe that scale should be allowed to accumulate to such an enormous amount in any boiler.

Another correspondent has drawn our attention to a pamphlet issued by a well-known boiler manufacturer which states:

"The Fidelity and Casualty Company reports that 34,046 boilers were examined internally by its inspectors during 1905, and 35,428 during 1906, and that defects were found as follows:

	1905	1906
Internal corrosion and pitting	1722	1372
Deposit of sediment	747	914
Scale and incrustation	2815	2167
Burned plates	136	194
Blistered plates	161	268
Bagged plates	972	707
Leaky tube ends	731	682
Leaky seams	680	647
Totals	7964	6951

"In the greater number of cases, the defect appears to be due to solid matter deposited from the water. As for the others, as pitting and leaky tubes and seams, it has been shown that pitting is due to acids held in solution in the water, or to air and gases contained in the water.

"The conditions revealed by these reports result yearly in an enormous loss to the owners of boilers. During 1906 there were, approximately, 350 explosions of steam boilers in the United States, resulting in the death of about 200 persons, the injury of nearly 500 more and damage to property of hundreds of thousands of dollars.

"Scale collects rapidly from waters of even fair purity. Nearly all ordinary feed waters contain scale-forming elements which, either alone or in combination with grease, will be precipitated, baked and hardened onto the boiler surfaces. In passing through or over the surface of the earth, water dissolves many substances and carries others in suspension. Bicarbonate of lime and sulphate of lime are the most common. When water is heated to about 200 degrees Fahrenheit, the expulsion of dioxide changes bicarbonates to mono-carbonates, and the mono-carbonates, being insoluble, are precipitated. If this occurs in boilers, a soft scale is formed, but in combination with sulphates or grease or oil such scale becomes dense and hard.

"Sulphate of lime and sulphate of magnesia remain in solution until a temperature of from 300 to 360 degrees Fahrenheit is reached. In other words, they pass on into the boilers, even though the water be heated previously and filtered, and, with the concentration from the boiling off of the water, in time form a hard, porcelain-like scale, difficult to dislodge and even more dangerous than the soft scale from the carbonates. In his 'Steam Boiler Economy,' Kent says: 'If the scale is dense and hard, so as to be practically waterproof, a thin coating of it may be an effective non-conductor and it may be a source of great danger as well as a loss of economy.'

"An immense amount of sediment can be carried into a boiler by apparently pure water. A 200-horsepower boiler running day and night for a week evaporates 1,008,000 pounds of water. An analysis of a certain water used for making ice, given in *Ice and Refrigeration*, for March, 1906, is as follows:

	Grains Per Gallon.
Carbonate of lime	39.16
Carbonate of magnesia	5.05
Sulphate of lime	9.30
Sulphate of magnesia	3.75
Total	57.26

"A week's run would therefore deposit 989 pounds of scale and sediment in the boilers, while in a month over two tons would collect. In this assumed 200-horsepower boiler there would be from 2000 to 2250 square feet of heating surface, or the equivalent of the floor of a room 46 feet square. One-fourth inch of scale spread over this surface would amount to 45 cubic feet solid, or over 72 feet when loosened up, which would make more than *two good wagon loads*.

"Scale ⅛ of an inch thick is not uncommon, and sometimes certain tubes of water-tube boilers are found entirely

*Superintendent of the departments of steam-boiler and flywheel insurance, Fidelity and Casualty Company.

closed. It has been estimated that scale 1/50 of an inch thick requires the burning of 5 per cent. of additional fuel; scale 1/25 of an inch thick requires 10 per cent. more fuel; 1/16 of an inch of scale requires 15 per cent. additional fuel; ⅛ of an inch, 30 per cent., and ¼ of an inch, 66 per cent. In his 'Mechanical Engineers' Pocket Book,' Sames says that 'scale of 1/16 inch thickness will reduce boiler efficiency ⅛, and the reduction of efficiency increases as the square of the thickness of the scale'."

Gas Engines Running and Under Construction

By C. W. Whiting

It is generally conceded by those who are conversant with the subject that gas engines have come into actual use to a considerable extent, and there has been some discussion as to how great that extent is, but definite knowledge on the subject is difficult to obtain. The writer has endeavored to gather sufficient data to make a fairly accurate estimate of the gas engines built and building in the United States, but this attempt unfortunately, has not been entirely successful, although considerable effort has been put into it. Nevertheless, some very interesting data have been obtained and these are given herewith.

As the first step in collecting the information, a letter was addressed to all companies known of by the writer who advertised that they manufactured gas engines. There were fifty-eight such companies, but two of them replied by saying that they had given up the gas-engine business. The letter asked for information as to the total number of gas engines built and under construction; the total rated horsepower of these engines, and the rated horsepower of engines built for natural gas, illuminating gas, producer gas, blast-furnace gas, and coke-oven gas, respectively. In some cases, replies were not very prompt and a second letter was sent to those who had not replied. This brought in a little more information. After a time, a third letter was sent out. All letters carried the sender's address on the envelop and none of them has been returned from the dead-letter office, although there has been ample time for such return. Those companies, therefore, who have intended to reply have done so. The companies addressed, omitting the two who had given up building gas engines, were as follows, the list being alphabetical:

Ajax Iron Works, Corry, Penn. Incomplete information.

Alamo Manufacturing Company, Hillsdale, Mich. Incomplete information.

A. H. Alberger Company, Buffalo, N. Y. No information.

Allis-Chalmers Company, Milwaukee, Wis. Full information.

Angola Engine and Foundry Company, Angola, Ind.

Backus Water Motor Company, Newark, N. J.

Bruce-Meriam-Abbott Company, Cleveland, Ohio. Full information.

Buckeye Engine Company, Salem, Ohio.

W. P. Callahan & Co., Dayton, Ohio.

Capital Gas Engine Company, Indianapolis, Ind. No information.

Central City Iron Works, Stevens Point, Wis. No response.

Central Machine and Tool Company, Battle Creek, Mich. No response.

Charter Gas Engine Company, Sterling, Ill. No information.

International Harvester Company, Chicago, Ill.

Jacobson Machine Manufacturing Company, Warren, Penn. No information.

Lambert Gas Engine Works, Anderson, Ind. No response.

Middletown Machine Company, Middletown, Ohio. No information.

Miller Improved Gas Engine Company, Springfield, Ohio.

Minneapolis Steel and Machinery Company, Minneapolis, Minn. Full information.

Model Gas Engine Works, Peru, Ind.

National Meter Company, New York, N. Y.

New Era Gas Engine Company, Dayton, Ohio.

TABLE SHOWING DATA RECEIVED FROM GAS-ENGINE BUILDERS.

Number of Company.	Engines Built and Building.	Total Rated Horsepower.	Average Rated Horsepower.	Horsepower on Natural Gas.	Horsepower on Illuminating Gas.	Horsepower on Producer Gas.	Horsepower on Blast-furnace Gas.	Horsepower on Coke-oven Gas.	Horsepower on Oil-vapor Gas.
1	14,491	275,000	19	30,000	100,000	10,000	.....	.....	135,000
2	4	2,900	725	.....	.....	2,900			
3*	1,200	7,200	6						7,200
4	2	200	100			200			
5*	1,700	25,500	15	6,375	6,375				12,750
6	95	11,340	119	4,715	55	6,570			
6*	1,600	32,000	20	29,000	3,000				
7	82	125,510	1,531	52,910	3,000	12,280	35,720		21,600
7*	70	7,000	100	3,000	1,000	3,000			
8*	5,500	44,000	8	8,000	700	100			35,200
9*	5,000	60,000	12	30,000	9,000	3,000			18,000
10	6	13,700	2,283	200			13,500		
11	128	14,550	114	3,000	1,000	10,550			
11*	2,000	20,000	10						20,000
12*	7,500	150,000	20	50,000	20,000	5,000			75,000
13	59	53,710	910	2,800	7,710	43,200			
14	130	10,167	78			10,167			
14*	60,000	360,000	6	120,000	120,000				120,000
15	286	12,818	45	10,854	1,429	535			
16	40	3,458	86			3,208			250
17*	1,000	8,000	8	1,200	4,800	800			1,200
18*	440	13,850	31	12,000	650	1,200			
19	56	9,555	171	9,055		500			
20	49	123,000	2,510	487		6,263	116,250		
21	30	2,250	75			2,250			
21*	15,000	105,000	7	2,100	10,500				92,400
22	250	25,500	102	25,500					
23*	520	13,000	25	13,000					
24	1,237	162,114	131	32,692	32,692	67,505	25,600	1,125	2,500
25*	20,000	120,000	6						120,000
26	54	20,254	375	1,127	9,100	10,027			
27*	3,500	187,500	54	1,250	185,375	875			
28*	1,000	10,000	10						10,000
29	3	150	50			150			
30*	9,000	45,000	5	15,000	15,000				15,000
31	1,507	14,653	10	9,594					5,059
32	635	35,395	6	31,835	640	2,920			
33	34	2,635	77	290		2,345			
33*	3,000	18,000	6						18,000
34*	60,000	300,000	5						300,000
	217,208	2,444,909	11.3	505,984	532,026	205,545	191,070	1,125	1,009,159

Columbus Machine Company, Columbus, Ohio.

Cook Manufacturing Company, Albion, Mich. No response.

De La Vergne Machine Company, New York, N. Y. Full information.

DuBois Iron Works, DuBois, Penn. No information.

Elyria Gas Engine Company, Elyria, Ohio. No response.

Fairbanks, Morse & Co., Chicago, Ill. Full information.

Foos Gas Engine Company, Springfield, Ohio. No information.

Fort Wayne Foundry and Machine Company, Fort Wayne, Ind. No response.

Havana Manufacturing Company, Havana, Ill.

Olds Gas Power Company, Lansing, Mich. Full information.

Olin Gas Engine Company, Buffalo, N. Y.

Otto Gas Engine Works, Philadelphia, Penn. Full information.

Peerless Motor Company, Lansing, Mich. No response.

Pierce-Crouch Engine Company, New Brighton, Penn. No response.

Pierce Engine Company, Racine, Wis.

George D. Pohl Manufacturing Company, Vernon, N. Y.

Power and Mining Machinery Company, Cudahy, Wis. Full information.

Providence Engineering Works, Providence, R. I. Full information.

Rathbun-Jones Engineering Company, Toledo, Ohio. Full information.

Riverside Engine Company, Oil City, Penn. Full information.

J. W. Ruger Manufacturing Company, Buffalo, N. Y. No information.

Snow Steam Pump Works, Buffalo, N. Y. Full information.

Springfield Gas Engine Company, Springfield, Ohio. No response.

Struthers-Wells Company, Warren, Penn. Full information.

J. Thompson & Sons Manufacturing Company, Beloit, Wis., Full information.

Titusville Iron Works, Titusville, Ohio. No response.

William Tod Company, Youngstown, Ohio. Full information.

Weber Gas Engine Company, Kansas City, Mo. Full information.

Western Malleable Iron and Manufacturing Company, Milwaukee, Wis. No information.

Westinghouse Machine Company, Pittsburg, Penn. Full information.

White & Middleton, Baltimore, Md. No information.

Wisconsin Engine Company, Corliss, Wis. Full information.

Witte Iron Works Company, Kansas City, Mo. No information.

Woolley Foundry and Machine Works, Anderson, Ind. No response.

It will be noted that, out of the fifty-six companies, eleven did not reply at all and eleven others refused to give any information. The remaining thirty-four were very kind and the writer takes this opportunity of thanking them, and especially those who supplied complete, itemized and accurate data covering their output; these are indicated by the note "full information."

The data received are presented in the accompanying table in the order in which the replies were received. The asterisks after the serial numbers of the builders indicate that the data given are approximate. In some cases, when two types of engine are being built, the data pertaining to one type are accurate and the data pertaining to the other type are approximate.

The oil-vapor gas column includes engines operated with gasolene but not crude-oil engines. It was not the original intention to include gasolene engines in the summation, but it was found quite impossible to separate them. A large number of the smaller engines are sent out by the manufacturers so equipped that they can be operated with gasolene, natural gas or illuminating gas. In some cases, therefore, it has been impossible to say with any certainty what sort of fuel these engines are using and the distribution of the smaller engines into the oil-vapor, natural-gas and illuminating-gas columns may not be strictly accurate. The summation does not include engines built for motor boats and motor cars, both of which types are, in reality, gas engines and very numerous. In the coke-oven gas column, there is only one lot of engines, but this is also inaccurate. There is at least one very large gas company which distributes coke-oven gas as illuminating gas and a number of the leading manufacturers have engines operating with this gas. There may be other such instances.

The total-output column foots up to 2,444,909 horsepower. Of this total, the accurate figures represent 918,859 horsepower and the approximate figures, 1,526,050 horsepower. If the approximate figures are 10 per cent. larger than the truth, the real total is 2,293,300 horsepower. This is the output of thirty-four manufacturers, and there are at least twenty-two manufacturers not represented.

Catechism of Electricity

The Electric Motor—Torque

788. *What is torque?*

The pull between the field magnet and the armature, which causes the armature of a motor to revolve. It is pronounced "tork" and is expressed in pound-feet, which is the product of the radius of the armature multiplied by the magnetic pull at its circumference, the radius of the armature being measured in feet and the pull at the circumference of the armature in pounds.

789. *What is the formula for calculating the torque of a motor?*

Let HP = Horsepower which the motor is developing,
S = Speed of the armature in revolutions per minute,
T = Torque in pounds at a radius of 1 foot = pound-feet.

Then

$$T = \frac{5252 \times HP}{S}.$$

790. *What is the torque exerted on the armature of a motor developing 50 horsepower, if its speed be 600 revolutions per minute?*

Substituting the known values of HP and S in the formula, the result is as follows:

$$T = \frac{5252 \times 50}{600} = 437.7 \text{ pound-feet.}$$

791. *How is the horsepower of a motor calculated when its speed and torque are known?*

By transposing the previous formula, as follows:

$$\frac{T \times S}{5252} = HP,$$

and using this transposition.

792. *Show the application of this formula to a motor running at 300 revolutions per minute and exerting a torque of 750 pound-feet.*

Substituting the respective values of $T = 750$ and $S = 300$ in the formula, the result is

$$HP = \frac{750 \times 300}{5252} = 42.8 \text{ horsepower.}$$

793. *What is the formula for calculating the speed of a motor when the horsepower and torque are known?*

Another transposition of the first formula, thus:

$$S = \frac{5252 \times HP}{T}.$$

794. *Illustrate the application of the formula, assuming a motor to give 10 horsepower with a torque of 100 pound-feet.*

$$S = \frac{5252 \times 10}{100} = 525.2$$

revolutions per minute.

795. *What relation exists between the torque and the current?*

Since the horsepower is proportional to the product of the voltage and current for which the motor is designed, and as the voltage is proportional to the speed, if volts $\times$ amperes be substituted for horsepower and volts for speed, with the proper multipliers, the resulting formula will show that the torque in any particular motor is always the same for a certain value of the current, whatever the speed may be.

796. *Explain this more fully.*

One horsepower is equal to 746 watts; therefore, volts $\times$ amperes $\div$ 746 = horsepower, or

$$\frac{E \times I}{746} = HP.$$

The voltage E is equal to the revolutions per minute $\times$ field strength $\times$ number of armature conductors $\div$ a number depending on the type of winding used, or

$$E = \frac{S \times \Phi \times w}{K}.$$

Therefore

$$S = \frac{E \times K}{\Phi \times w}$$

and horsepower $\div$ revolutions per minute are equal to

$$\frac{HP}{S} = \frac{E \times I \times \Phi \times w}{746 \times E \times K}.$$

Cancelling out the two E's,

$$\frac{HP}{S} = \frac{I \times \Phi \times w}{746 \times K}.$$

Now the field strength Φ, the number of wires w and the number K all remain fixed in an ordinary motor, so that

$\frac{HP}{S}$ is proportional to I,

and as the torque varies exactly with $\frac{HP}{S}$, it also varies directly with the armature current I, and is not affected by the speed alone.

797. *Mention some of the factors which limit the horsepower at which a direct-current motor can be rated.*

The speed of rotation, sparking at the commutator, and the heating of the parts; in other words, the power of a motor to

keep up to normal speed, to commutate well, and to remain sufficiently cool in operation.

CONSTANT-POTENTIAL MOTORS

798. *Are electric motors always supplied with power from a constant-potential source?*

No, electric power may be supplied to a motor either at a constant voltage or at a constant-current value.

799. *How does the regulation of speed compare in the two cases?*

With a constant-voltage supply, good regulation is comparatively easy to obtain, while with a constant-current supply a special regulator must be provided to prevent the speed from becoming excessive at light loads; this will be explained in detail later.

800. *Are the armature and field currents constant in a constant-potential shunt-wound motor?*

If a constant voltage be maintained at the terminals of the motor, the current through the field-magnet coils will be constant after the coils have warmed up. The current through the armature, however, will vary in strength according to the load, its value being determined by the torque required to overcome the backward pull of the load.

801. *Are the armature and field currents constant in a constant-potential series-wound motor?*

No. The armature current of a series-wound motor varies according to the load requirements, and as the field winding is in series with the armature, the current in that winding is the same as the current in the armature winding and therefore varies.

802. *Does the current in a series-wound motor vary as much as that in a shunt-wound motor armature?*

Not with the same change in load. When the current in a series-wound motor increases, it strengthens the field and thereby increases the torque in addition to the increase due to the larger armature current. Therefore, a given increase in load demands less increase in current than in the armature of a shunt-wound motor, the latter having a constant field strength; thus, to a certain extent, automatically controlled according to the requirements, making the series motor very nearly self-regulating as regards current.

803. *Is a shunt-wound motor self-regulating as regards current?*

It is self-regulating, but it does not vary the armature current exactly in proportion to load changes, because the armature current exerts a demagnetizing effect on the field magnet which weakens the field slightly when the armature current increases, and this decreases the torque. Consequently, the armature current must increase in slightly greater proportion than the increase in load.

804. *Does the speed of a shunt-wound motor vary greatly, when current is supplied at constant voltage?*

No; the smallest motors vary as much as 10 per cent. from no load to full load, but motors of moderate and large sizes vary only from 2 to 4 per cent.

805. *Can such motors be made to operate at different speeds?*

Yes; constant-potential motors are made to run at widely different speeds.

806. *Describe the usual methods of regulating the speed of a shunt-wound motor.*

It has already been explained that weakening the field strength of a motor reduces the counter electromotive force generated in the armature, and this tends to increase the speed of rotation. The field of a shunt-wound motor may be weakened by introducing resistance in its circuit, either by hand or automatically, or by altering the ampere turns in any other manner, and this is one means employed to obtain various speeds from a given machine. Another method of changing the speed consists in changing the applied electromotive force by varying the resistance in the field of the generator supplying the power. This method, in general, can be used only when there is one motor supplied by the dynamo, for if there are others the speeds of all will be changed.

Edwards Air Pump Improved

BY S. R. STONE

In the accompanying illustration, Fig. 1, is shown the sectional elevation of a new air pump designed for the New York City Railway Company, 22 of which are to be used in connection with the Tomlinson barometric condensing system installed in the Ninety-sixth street power station. Eight are already in service.

This type of air pump, known as the "suction valveless" pattern, had its origin in England, about 1845, having been invented by Bodmer and long known under his name. Since that time various modifications of the Bodmer pump have been brought out by European manufacturers, the best of which is undoubtedly the Edwards pattern, extensively built and sold under license in the United States. This style of pump, shown in Fig. 2, avoids inlet-opening valves and valves in the bucket, yet removes both air and the water of condensation quickly and effectively. Its action may be briefly outlined as follows:

Condensed steam and air flow into the lower recess *A* through the passage *B* from the condenser. As the cone-shaped bucket descends, it forces the water from *A*, so that it shoots up through the ports, as at *C*, into the cylinder *D*. The bucket, rising, closes the ports and catches the water and air in the cylinder, forcing them out through the valves in the head, as shown at *E*, into the discharge chamber *F*, whence the mixture passes out through the pipe *G* to the hot well or feed-water heater.

A radical improvement on this type of pump has now been made for the New York City Railway Company by the Allis-Chalmers Company, by adding an air connection (Fig. 1) just under the dis-

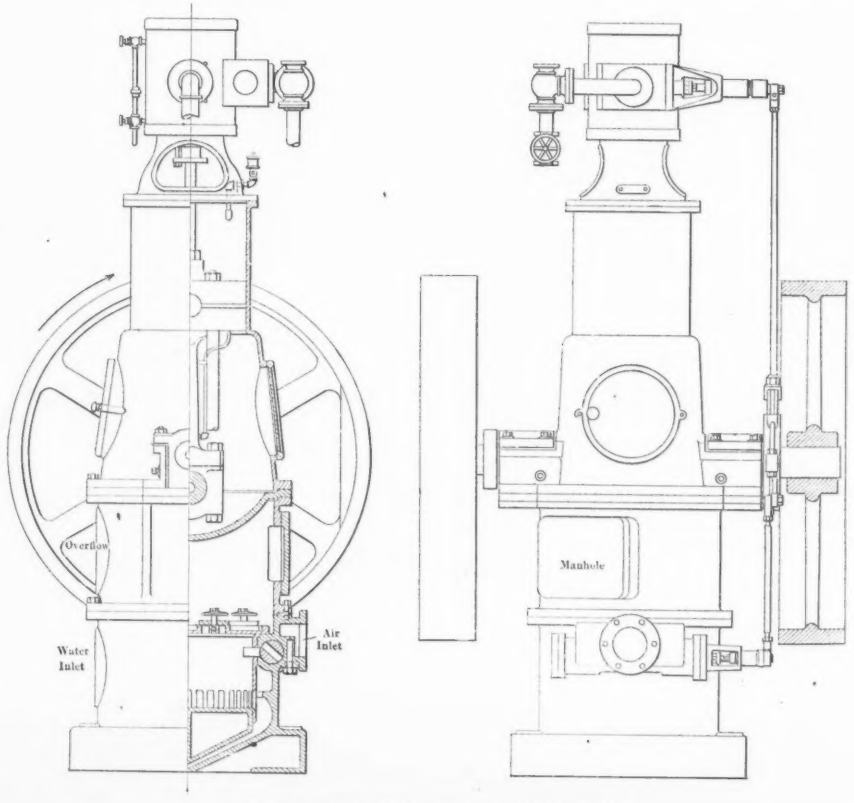


FIG. 1. NEW DESIGN OF EDWARDS PUMP

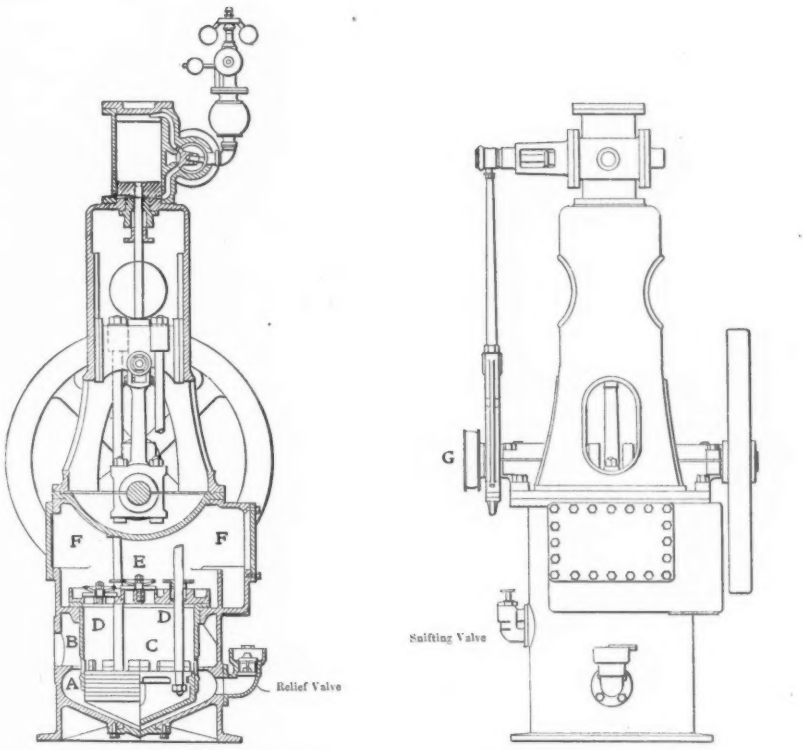


FIG. 2. EDWARDS PUMP AS FORMERLY DESIGNED

charge-valve deck of the pump barrel. In this opening, close to the cylinder wall, there is a valve positively actuated by an eccentric on the shaft. The design of this is similar to that of a Corliss engine valve, and it opens at the beginning of the down stroke of the bucket, thereby giving direct communication between the pump cylinder and that part of the condenser from which it is desired to draw the air.

In the Bodmer design and its principal modification, as standardized by Edwards, no air can flow into the pump from the condenser until the ports *C* are open, when the bucket is nearly at the end of its stroke; but, with the improved arrangement, air is flowing into the pump during the entire down stroke. As the bucket starts on its upward movement, the air valve closes, and the air is forced through the discharge valves *E* against atmospheric pressure, together with the water which has been dashed around the periphery of the bucket and through the ports *C* into the pump cylinder.

The capacity of the pump is considerably increased by this arrangement, making it practically a dry-air pump on the down stroke and a wet-air pump on the up stroke. In effect, therefore, it is double-acting, while the ordinary air pump used with condensers is single-acting. The pump is installed separately from the other apparatus and can be used for either surface- or jet-condenser service, in capacities from 100 to 5000 horsepower. As will be seen from the illustrations, the steam end is of the crank and flywheel type and built after a design familiar to all power users.

Modern Science Club Meeting

The Modern Science Club, of Brooklyn, N. Y., gave a reception to the newly elected national officers of the N. A. S. E. who live in the vicinity on Tuesday evening, September 29. The club parlors were filled to overflowing. During the evening there were talks by W. J. Reynolds, the newly elected national vice-president, and Thomas H. Cole, national conductor. Fred L. Johnson, associate editor of POWER AND THE ENGINEER, past president of Massachusetts State Association, N. A. S. E., made an address which was pleasing and instructive.

The entertainers for the evening were: "Charlie" Thompson, "Billy" Murray, John Tracy, of Jenkins Brothers, "Bert" Self, of the Keystone Lubricating Company, H. J. McMahon, of the Royal Eastern Electrical Supply Company, and "Jack" Armour, of POWER.

It is thought likely that the club will have to secure a larger clubhouse soon, owing to the increasing attendance at its meetings and social events.

Merrimac Valley Association Outing

The third annual outing and clambake of the Merrimac Valley Association, N. A. S. E., which includes the Nashua, Lawrence, Haverhill and Newburyport associations, was held at Moulton's Grove, Johnson's Pond, South Groveland, Mass., on September 27. This combined event always brings the "boys" out, and as the day was a most delightful one, the gathering was unusually large. A "rattling good" shore dinner was served, and plenty of other refreshments were on tap.

The event of the occasion was a tug of war between teams from the Lawrence and Haverhill associations, which resulted in a tie after three hotly contested trials, State Deputy Kearney acting as referee. There was a boat race between Messrs. Connelley and Watson, of Lawrence, and Messrs. Hogan and Hart, of Boston. The distance was three miles, and after the slowest race ever rowed by human beings, relief came when the Boston team was declared the winner.

Invited guests who made addresses were Past National Presidents T. N. Kelsey and P. H. Hogan, Past State President Fred L. Johnson, State Deputy E. H. Kearney and "Jack" Armour.

Evening Technical Courses

The Polytechnic Institute, of Brooklyn, N. Y., announces the opening of its 1908-09 season of evening extension courses for engineering students on October 1. These courses are designed to meet the requirements of practicing engineers, and include both graduate and undergraduate work, the latter qualifying successful students for the usual engineering degrees after completion of the prescribed courses of study. In the department of mechanical engineering, in charge of Prof. William D. Ennis, courses are offered this year in steam engineering, gas power, works engineering and a license course for engineers, by Professor Ennis; in experimental engineering, by Prof. W. J. Moore; in machine design, by Prof. Magnus C. Ihlseng; and in mechanical drawing, by Morgan G. Farrell. Other courses offered by the departments of civil and electrical engineering and chemistry are also of interest to candidates for the M. E. degree. Besides 64 graduate students holding engineering degrees from various institutions, 364 other students participated in similar evening courses last year.

Evening technical courses for young men employed during the day were inaugurated at the Pratt Institute, Brooklyn, N. Y., on September 28 and will continue until March 27 next. Of especial interest is the class in "steam and the steam engine." This class has been planned especially for stationary engineers and their helpers. Additions have been made to the laboratory apparatus, which now include seven different types of steam and gas engines and nine pumps and hydraulic motors fitted for testing. A class in "strength of materials" is also intended for practical men.

POWER AND THE ENGINEER

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The New York Board of Education Suspends the Use of Oxalic Acid

On Wednesday afternoon, September 30, Commissioners Thomas J. Higgins and Nicholas Barrett, chairmen, respectively, of the committees on janitors and supplies of the New York Board of Education, held a hearing to determine whether oxalic acid and salt should be continued as a fuel-saving compound in the department.

The hearing developed the fact that Patrick Jones, superintendent of supplies, is the man who has led the department into the use of the "ash-burning" compound. Full of zeal for his department, he snapped at the saving which might be made in the half-million-dollar coal bill of the Education Department, if the cobbler's formula had one-half the merit claimed for it.

Andrew J. Maguire, supervisor of janitors, was quite willing to coöperate for a possible saving, and signed the circulars directing the men under him to give the compound a fair trial.

Out of the five hundred odd men in charge of school plants a considerable majority reported that savings of from ten to thirty per cent. had been effected, and Mr. Jones, feeling justified in the assumption that the experiment had proved a success, had made arrangements for ordering eight tons of oxalic acid and twenty-seven tons of rock salt, when the remonstrances of the engineers among the working force began to be effective. Mr. Maguire had traced up many of the cases of reported saving and had found them to be merely apparent, or accountable for upon rational grounds, and he and the engineers under him objected to being made the butt of the ridicule of engineers all over the country for being compelled to conform to a practice which they knew to be charlatanic and unscientific. He, therefore, objected to the purchase and continued use of the chemical, and the hearing was the result.

Of the many witnesses who had been summoned few were called. The testimony soon turned to the effect of the chemical upon the shell and tubes of the boiler. Several witnesses testified that it was deleterious, samples of deposit were produced and instances of leaky tubes cited, whereupon Commissioner Barrett and Mr. Jones announced that any further hearing was unnecessary, as whatever the facts might be as to a possible saving, they did not wish to attempt it at the expense of and hazard to the safety and integrity of the boilers.

The impression upon a disinterested observer would be that Mr. Jones is very much in earnest and is honestly deceived in the matter. With no technical nor practical engineering knowledge upon which to base an analysis of the results of his experiment he naturally came to the conclusion that the saving reported by his subordinates was the result of the use of his compound. And so it was in a way. The understanding that a saving was expected from its use and must be made if a janitor was to preserve his standing, the natural desire to avail themselves of the opportunity afforded by this circumstance to please a superior and to obtain favor at court, and the enforced refiring of the ashpit refuse with the large amount of carbon which it contained, which the use of the compound involved, put the janitors upon their mettle and produced the saving which can be made in nine plants out of ten by interested attention and improved methods. The compound was the talisman that effected this and it is not strange that Mr. Jones confounds the talisman with the cause.

Now that it has been shown that the schools can run upon so much less coal than they had been using it will be incumbent upon the superintendent or janitors to see that care is not relaxed and former careless methods resumed. His inspectors should collect at unexpected times samples of ash which should be analyzed and the janitor of a school the ashes from which habitually ran high in carbon should be first instructed, then called to account and finally discharged if the condition continues. This is, perhaps, more in the nature of a club than of a talisman, but it is orthodox and has the advantage of bestowing credit upon the man who is doing the best work instead of upon the man who can show the greatest saving because he has been making the most waste.

Competition

It has been intimated that the competition of the turbine with the reciprocating engine has aroused the engine builders to a sense of the responsibility resting upon them. It is doubtful, however, if the presence of the turbine in the field has exerted any particularly stimulating influence upon steam-engine designers. Competition between themselves, the spirit of emulation, and the natural desire upon the part of the designing engineer to make his own product the best of which he is capable have combined to form the mainspring of the desire for higher efficiency. It is highly probable that the same degree of perfection existing in the engine today would have been reached sooner had the turbine not entered the field at all, for much of the talent and means that have been and still are being used in the evolution of the turbine would have found a profitable field of work in the higher development of the steam engine.

It was not competition that forced Watt or Stephenson to the great work of their lives; it was not competition that drove George H. Corliss to give expression to

the belief that he could make a better steam engine than had ever been produced, nor was it competition that compelled De Laval, Parsons and Curtis to give the world the best that was in them in making the turbine a commercial possibility. It could hardly have been even the thought of competition that led to the working into a coherent whole the thousand and one details that went into the design of the power plant at Redondo, Cal. Most men who do things like this are actuated by motives higher than the desire to meet competition; higher than the sordid ambition to get a part or the whole of another's business by giving the smallest possible per cent. more than a competitor for the same price. These things are a part of the lives they live. They do these things and give their great works to the world, with no thought of reward and with no fear of competition, because it is in them and must find expression. They do these things because they cannot help it.

Belt versus Direct Drive for Steam Engine Governors

It has been repeatedly stated that the steam engine of today is as nearly perfect as it will ever be, both as to efficiency and operation. We do not dispute that it has been brought to a state bordering on perfection, with due regard to economy, but considering mechanical construction there is still opportunity for radical improvement. This applies especially to the practice of using a belt-driven governor rather than one positively driven. The early method of operating the governor was by means of a belt, which has become so common that it is accepted by many as the only feasible method; while to others it is so common as to excite no comment, and the evils attending the practice are scarcely noticed. If engines found operating with belt-driven governors were of ancient design, there would be some little excuse for using such an unmechanical, not to say dangerous, device.

Nothing about the factory gives as much trouble as belting (if it is not the belt itself, it is the lacing), and yet the mechanism upon which steady speed, economical operation and safety of a steam engine depend is actuated by a belt. Surely the governor action which depends upon the slight variation of its own speed corresponding to the variation of the engine speed should be controlled by a type of drive more trustworthy than leather belting, albeit that this method of governor drive would not be open to such adverse criticism if it were not that so many engineers believe that almost any kind of a belt will answer.

Oil-soaked belts are numerous, and it is not uncommon to see them so saturated that the oil is forced to the surface of the belt where it passes the face of the pulley. Also, belts containing several pieces laced together are not exceptional, and lacing on the verge of giving out may be found all too often. Such conditions are not conducive to safe operation. If a positive drive were adopted for engines, where applicable, many flywheel explosions and wrecked engines would have been avoided, and while the direct-driven method may have its disadvantages, it is much superior to belting from every reasonable standpoint.

The steam plant is filled with various devices designed to prevent accidents and destruction of property. We cannot conceive, therefore, why the direct drive has not received more attention, when so many serious accidents can be traced directly to the failure of the belt driving the governing device.

Making the governor belt endless, thus doing away with lacings, does not eliminate the objection to this type of drive. An engine may be equipped with a safety device, but safety devices do not always operate. The greatest danger does not lie in the breaking of the governor belt, dependence being placed upon the safety device to shut down the engine, but it does lie in the oily belts which slip to such an extent that the governor is not kept up to speed, thus allowing a longer range of cutoff than is required for the load carried; and as a result, the engine speeds to the danger limit.

In writing the foregoing the experience of Charles T. Porter with positive- and belt-driven governors, as told in his "Engineering Reminiscences," recently published in POWER, has not been overlooked. Undoubtedly the vibration and shock due to ever-changing load and speed would work serious havoc to some types of governor as now constructed, but this does not mean that this difficulty cannot be overcome.

Several familiar types of engine are operated with positive-driven governors, and we know of no fault connected with their operation attributable to this cause. These engines are used for all kinds of manufacturing purposes and no record of frequent governor failures stands as a protest against them, or the direct method of governor drive.

If a positive inflexible connection between the main shaft and the governing mass were inadvisable it would be easy to introduce an elastic connection and still preserve a positive transmission which would be more mechanical and safer than the slimpsy belt to which the majority of engine users pin their faith.

Cycle

A cycle, in engineering, is an established succession of events which when concluded leaves all related conditions exactly as they were immediately before the cycle began. For example, if an elevator starts upward from the third floor of a building goes up to the top, then to the bottom and then up to the third floor, that would constitute a complete cycle of elevator travel, if that elevator regularly traveled the route described. Since elevators, from the nature of their service, do not always stop at the same floors in the same sequence, there is no recognized elevator cycle, nor is there any need for one. The example will serve, however, as a simple illustration of the definition of "cycle."

A gas-engine cycle consists of five events which invariably occur in the same sequence during correct operation; they are suction (the intake of the charge), compression, combustion, expansion and expulsion (exhaust). No matter what the type of the engine, these five events constitute one cycle. In the Otto type of engine, four piston strokes are required to carry out the complete cycle, the charge being drawn in during one stroke, compression being effected by the next stroke, combustion occurring immediately after compression, expansion occurring during the third stroke and expulsion during the fourth. The next stroke is the first one of the next cycle. In the Clerk type of engine, all of these events are crowded into two piston strokes. Hence the Otto type of engine, commonly referred to as the "four-cycle" engine, is a "four-stroke" engine and the Clerk type is a "two-stroke" engine. These elementary facts have been explained so often that it rather surprised and disappointed us to receive recently a contribution from a technical graduate in which the Otto engine was credited with having "four cycles, namely, suction, compression, expansion and exhaust!"

The electrical "cycle," carried out in all alternating-current circuits, is not made up of dissimilar events, as in the case of the gas engine. There are four "events" but they blend into each other, one forming either a continuation or a reversal of the one preceding it. One cycle consists of a rise of electromotive force from zero to maximum in one direction (say positive), a fall back to zero, a rise to maximum in the opposite direction (say negative) and a fall to zero again. The electromotive force then rises to maximum (positive) again, beginning the succeeding cycle, and so on, continually repeating the cycle. The current in the circuit follows exactly the same cycle; so does the magnetic flux in any electromagnet "excited" with an alternating current.

Bogus Subscription Agent Sentenced

In the last number of POWER AND THE ENGINEER we noted the arrest of Joseph M. Sheeran, who had been fraudulently representing himself as a subscription agent for this paper. Sheeran was tried on October 2, found guilty and sentenced to one year in jail.

There are a couple of other men engaged in the same crooked business as Sheeran; we are on their trail and expect to be able to round them up before long.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Lea-Degen Turbine Pump

As a result of nearly four years' work devoted to the development of turbine pumps, the Lea-Degen high-duty turbine pump, built by the Lea Equipment Company, 136 Liberty street, New York, has been perfected. This type of pump is made in separate units designed for heads of from 7 to 1000 feet, or higher, with capacities ranging from 100 gallons to 30,000 gallons per minute. They are both horizontal and vertical. It will be seen from Figs. 1 and 2 that it is possible to assemble any number of stages desired, and by the use of a small number of standard parts a great variety of combinations can be produced. Fig. 3 shows a single-stage pump, any number of which may be connected as one pump. This arrangement does not interfere with the inspection after the sections are bolted together, as the top can be easily removed.

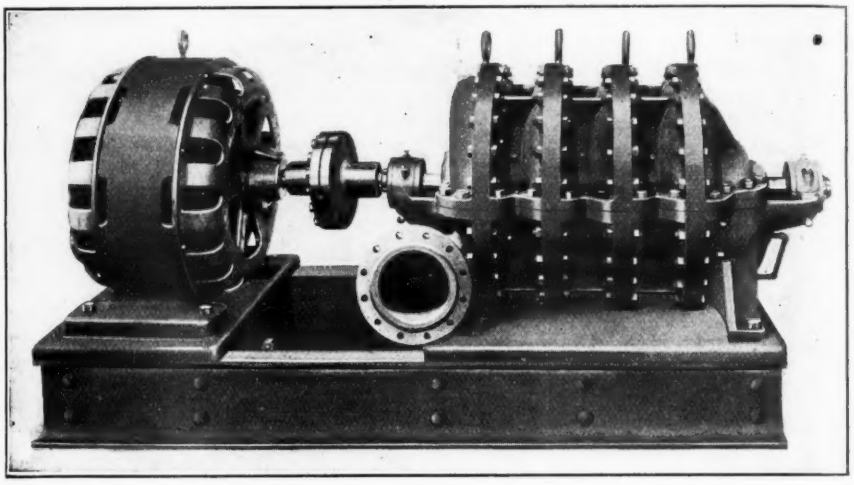

FIG. 1. FOUR-STAGE LEA DEGEN HIGH-DUTY TURBINE PUMP

The general design of the pump consists essentially of shrouded pump-wheel runners mounted on the same shaft in a case. The case is so partitioned that the water is drawn from the source of supply and put under pressure by the first wheel and delivered to the suction chamber of the second wheel, this operation being repeated as many times as there are runners. In passing from the first to the second wheel the water passes through passages formed in the casing by means of ribs, or deflectors, which take the water from the first wheel in the direction in which it leaves such wheel, conveys it by an easy spiral path to the second wheel, and so on to each succeeding wheel.

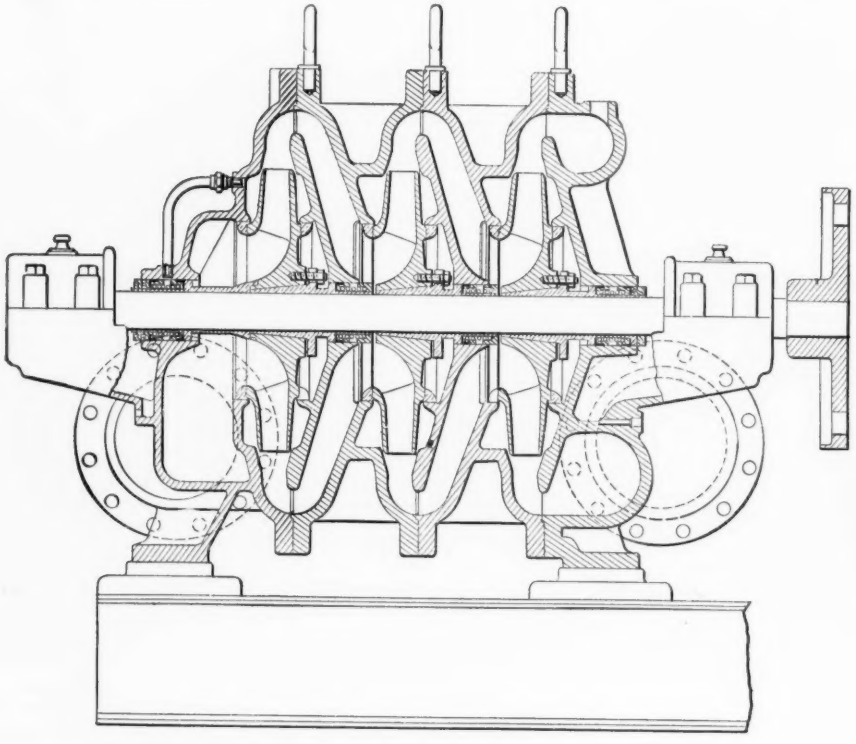

FIG. 2. SECTIONAL VIEW OF LEA-DEGEN TURBINE PUMP

The passages or nozzles from one stage to the other gradually increase in area in the direction of the flow of water, so that the velocity of the water imparted by the first wheel is gradually transferred in these passages into pressure and little, if any, energy is said to be lost through eddy currents in the passage of the water from one impeller to the next. The combined effect of giving the water the spiral direction in the passages, and at the same time gradually decreasing its velocity and transforming it into pressure, has much to do with the efficiency of this pump.

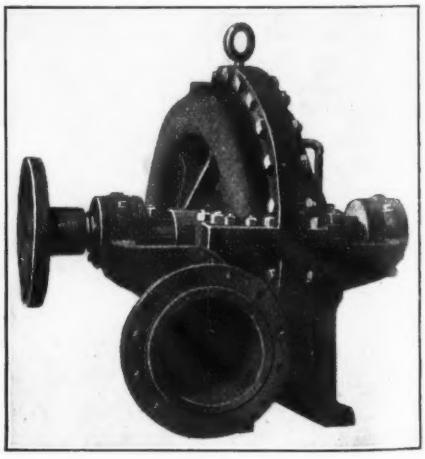

FIG. 3. SINGLE-STAGE LEA-DEGEN PUMP

By means of bolted circumferential divisions of the case, provision is made for either using the suction and discharge end of a case together as a single-phase pump, or for adding as many intermediate sections as may be necessary to afford any desired pressure at any first speed. From this it will be seen that additional stages can be installed after a pump has been in operation without wasting any part of the original case.

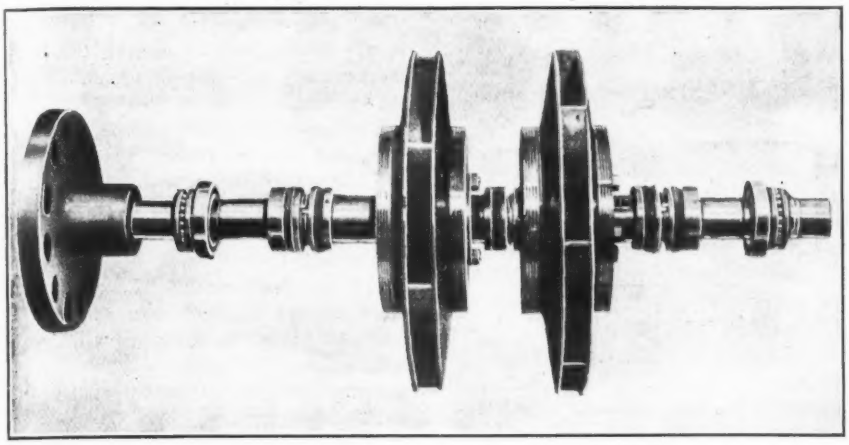

FIG. 4. RUNNER OF A LEA-DEGEN TURBINE PUMP

The packing consists of right-angled cup leathers held in place by springs in such manner that they are tight under all conditions and allow the shaft to oscillate throughout any distance necessary. It is believed that the packing will not be affected by the wear of the shaft or sleeves. The leather cups are designed to be held against a flat collar on extended pump sleeves so they will counteract any wear of the cups or collars, while the shaft may be shifted at will in either direction, with the leathers following, without changing the location of the leather with relation to the shaft collar, thus making a practically water-tight joint. To insure the leathers seating against the collars before pressure is put on the pump, a spiral spring is used between each pair of cup leathers. Provision is also made for setting out the leather packing on the suction end of the shaft by the water pressure of the high side of the pump. Fig. 4 is a view of a runner, in which the automatic packing is shown to good advantage.

A ball thrust bearing, with adjustable collars, for shifting the shaft endwise to balance the end thrust of the pump runners, is placed on the outside of the main bearing at each end. The balancing is accomplished by means of variation in the width of the water space on both sides of the wheel between the rim of the wheel and the case.

Both suction and discharge connections are placed below the center line of the pump, thus allowing the renewal of the top without breaking the water line, and at the same time they are in such shape as to give practically no obstruction to the easy flow of the water.

The wheels and shaft are held together by taper, drawn sleeves, allowing the easy removal of the impellers. These sleeves cover the shaft throughout its exposed parts and form a part of the automatic packing.

The bearings are of the self-oiling type, having no connection whatever with the suction or discharge line, therefore it is impossible for water to leak into them. These features are distinctly shown in Fig. 2, which is a sectional view of the pump.

The following show the results of a test under conditions of maximum efficiency, which was carried out by James E. Denton, professor of mechanical engineering, Stevens Institute of Technology:

At 400 revolutions 77.7 per cent. efficiency with a capacity of 2290 gallons under 43.6-foot lift.

At 500 revolutions 77.6 per cent. efficiency with a capacity of 2794 gallons under 67.4-foot lift.

At 600 revolutions 77.9 per cent. efficiency with a capacity of 3235 gallons under 100.7-foot lift.

A New Sturtevant Motor

B. F. Sturtevant Company, Hyde Park, Mass., has brought out a new line of four-pole electric motors, designated as "Type H." These machines are suitable for general commercial work, such as operating machine tools, but their characteristics have been considered chiefly as regards the driving of fans. For example, they are very conservatively rated in order to prevent a sudden increase of load injuring the motor. They are guaranteed to carry 50 per cent. overload for one hour and 100 per cent. overload for five minutes without destructive sparking or heating. By special design of armature abundant ventilation is secured, the air currents flowing in and out of the motor as indicated in the section. The heat rise is always low; tests conducted in clean, dry places are said to show less than 40 degrees Centigrade (72 degrees Fahrenheit) at normal speed and output.

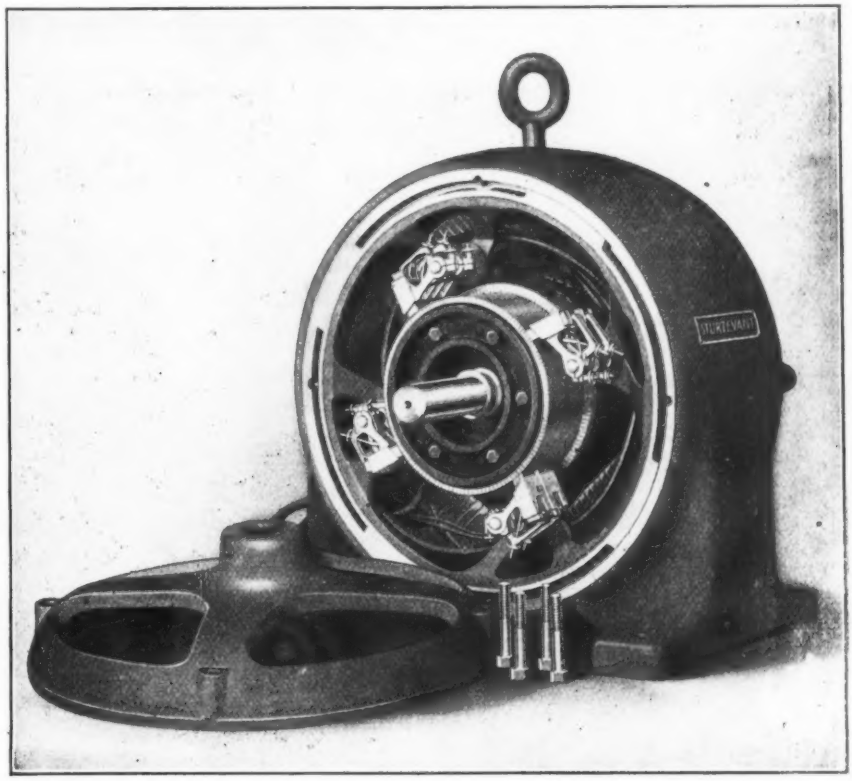

FIG. 1. STURTEVANT MOTOR WITH ONE JOURNAL BRACKET REMOVED, SHOWING BRUSH RIGGING

The magnet frame consists of a cylindrical yoke of cast iron machined on each end to receive the bearing brackets and on the inside to provide seats for the

magnet cores, which are through-bolted to the frame. The magnet cores are located off-center to permit the use of duplicate bearing brackets on both ends.

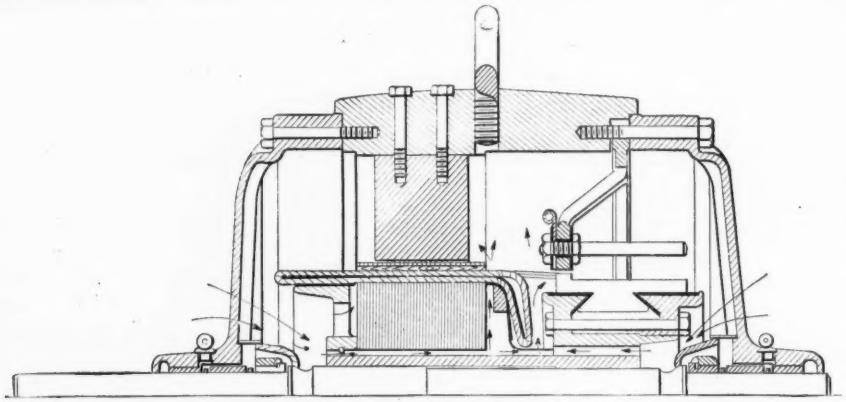

FIG. 2. HALF SECTION OF STURTEVANT MOTOR, ILLUSTRATING AIR CIRCULATION THROUGH ARMATURE

By taking out the through-bolts, a magnet core with its coil may be removed without disturbing the armature or dismantling the motor. The magnet cores are built up of soft-steel punchings, secured between end plates under pressure. Cast-iron pole tips eliminate the humming which is usually involved by the use of laminated construction.

The field-magnet coils are machine-wound of double cotton-covered copper wire and are thoroughly insulated and protected against both moisture and mechanical injury.

The armature is of the iron-clad, slotted drum type, built up of soft-annealed sheet-steel punchings insulated from each other and assembled on a cast-iron sleeve. The sleeve is provided with openings for the circulation of air and has an extended hub for the reception of the commutator shell. The armature and commutator form a self-contained unit. The commutator is built up of bars of hard-drawn copper, carefully insulated with the best mica, and is held in a cast-iron shell of spider construction. The mica rings which insulate the segments from the metal clamping rings are of the best quality; the commutator is assembled under great pressure while hot, in order to prevent loose bars. The commutator bars are provided with risers into which the leads from the armature coils are soldered, which permits the connection of the leads with little bending and reduces the liability to short-circuits at the back end of the commutator.

The brushes are carbon blocks, fed through brush holders which are supported by arms projecting from a ring which is mounted in a recess machined in the magnet frame. The ring is clamped in position by the bearing bracket, and while it may be shifted easily, there is no danger of the brushes being thrown out of position or tilted. Each brush is provided with a braided-copper cable connector or "pig-tail," relieving the brush-holder body and springs from carrying the current.

The supporting feet of the motor are cast solid with the frame. The pole pieces are located off-center with respect to the frame; this construction permitting the use of duplicate bearing brackets on either end.

The bearing brackets of skeleton construction are clamped into seats in the magnet frame by four equally spaced bolts so that the motor may be arranged for floor, wall, or ceiling suspension without further machine work.

These motors are built in sizes giving outputs of 1 to 100 horsepower, and the speeds range from 425 to 1600 revolutions per minute.

Personal

J. M. Robertson, for more than thirteen years with the Montreal Light, Heat and Power Company, or its predecessors, has resigned as mechanical superintendent and superintendent of shops and has established a consulting-engineering office at Montreal.

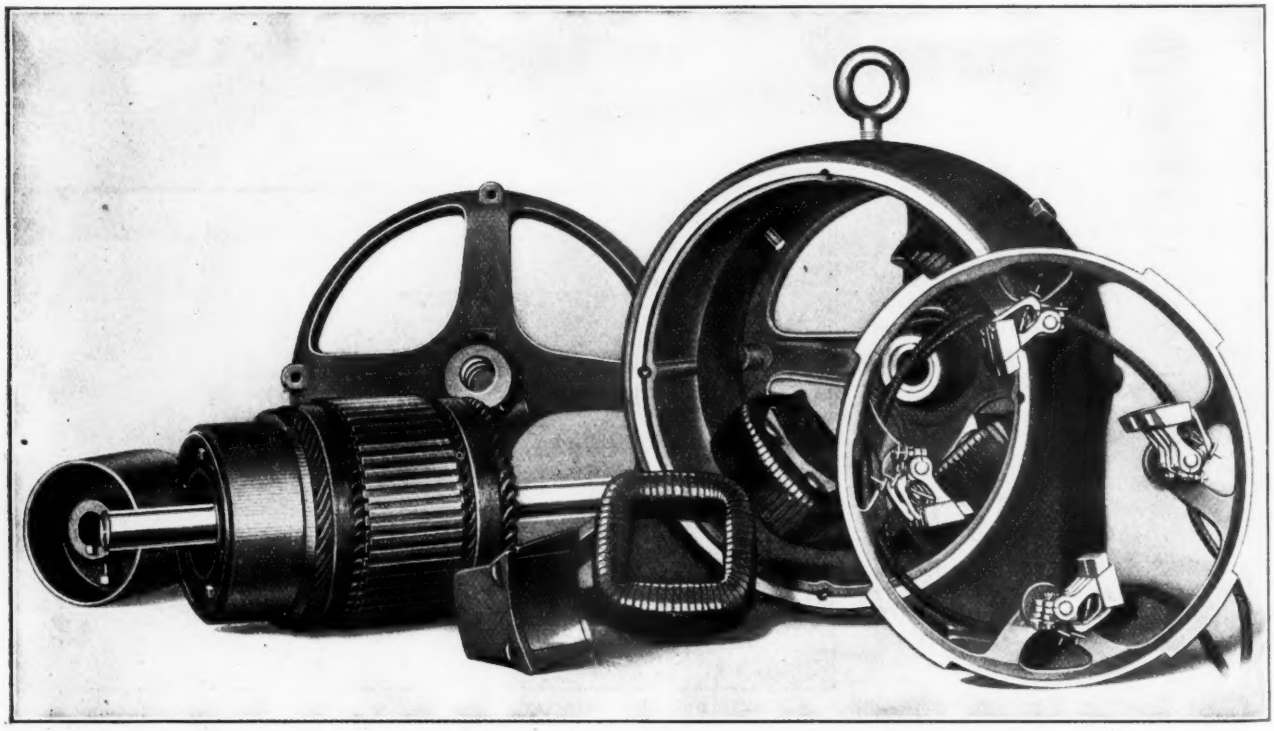

FIG. 3. COMPONENT PARTS OF STURTEVANT MOTOR

The combined associations of engineers of the Borough of Brooklyn, N. Y., will hold an entertainment and reception at Prospect hall, Friday, November 13.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Steam Supplied to an Engine by its Boiler

When an engine is said to use a certain number of pounds of steam does it mean that the same number of pounds of steam are taken from the boiler?

F. L. J.

Not necessarily. Every boiler primes more or less and the engine should not be charged with the water that goes to it as water and not as steam. Suppose that the steam which the boiler furnished contained 4 per cent. of moisture; then for every pound of dry steam used by the engine 1.04 pounds of feed water would have to be pumped into the boiler, assuming no loss by leakage, of course.

Running a Belt with an Idler

Will a belt last longer by running it tight over the idler or by running it as slack as possible to do the work?

F. L. J.

An idler when used as a tightener shortens the life of the belt. An idler should be set so as to give more "wrap" of the belt around the working pulley, and the belt should always be run as slack as possible without slipping.

Why the Babbitt in the Pillow Block Melts

A 500 horsepower cross-compound engine, direct-connected to a generator, is continually melting or wearing the babbitt out of the pillow block on the low-pressure side, while the pillow block on the high-pressure side remains intact.

The engine is newly erected, runs at 125 revolutions per minute and I am sure the shaft is in perfect alinement. Is the speed of 125 revolutions per minute too high for this engine?

O. B. H.

It would seem from your description that the cause of the trouble must lie in the condition of the shaft on the low-pressure side of the engine. With the shaft round and smooth it should run equally well at both ends. The fact that one end runs well proves that the speed is not too high.

How to Calculate Diameter of Water Piston of Pump

How shall I calculate the diameter of the water piston of a boiler-feed pump to supply a boiler of any given horsepower?

H. J. M.

A boiler horsepower is the capacity or ability to evaporate thirty pounds of water per hour. As it is good practice to operate a feed pump slowly and continuously, a pump which at its normal speed will supply twice as much water as the boiler evaporates under ordinary conditions should be selected. When the length of stroke and the number of strokes per minute are given, multiply the number of gallons wanted by 231; divide this product by the number of strokes per minute, and this quotient by the fraction 0.7854; then extract the square root of the result and this will give the diameter of the water piston.

Suitable Chimney Dimensions

I have four horizontal return-tubular boilers, 6x16 feet, with 68 four-inch tubes and 33 square feet of grate surface. They are rated at 125 horsepower each and I would like to have you give me the dimensions of a suitable brick chimney for draft.

T. E. W.

A good practical rule for estimating chimney hight and diameter is: Make the area of the chimney one-seventh of the grate area and twenty-five times its diameter in hight. This would give a chimney 4 feet 8 inches in diameter and 115 feet high. If all the boilers are not to be operated at the same time, the diameter and hight may be reduced. For 536 boiler horsepower Kent allows a chimney 5 feet in diameter and 90 feet high, and for 503 horsepower 4 feet 6 inches in diameter and 125 feet high. These estimates are based on the assumption that five pounds of coal is burned per hour for each boiler horsepower.

Size of Pump Suction Pipe

Explain why a suction pipe to a pump cannot be made longer than 34 feet and have the pump work successfully.

J. B.

The water is pushed up the suction pipe by the pressure of the atmosphere, which is ordinarily, at the sea level, about 14.7 pounds per square inch, or

$$14.7 \times 144 = 2116.8$$

pounds per square foot. A cubic foot of water weighs something over 62 pounds at ordinary temperature, so that the atmospheric pressure on its base would support a column less than

$$2116.8 \div 62 = 34 \text{ feet.}$$

It makes no difference what the diameter of the column is, for the area of the base, and thus the supporting pressure, varies in the same proportion as its weight.

Effect of Increasing Angle of Advance

What effect, if any, has increasing the angle of advance of a plain slide valve on the amount of port opening?

J. B.

No effect, except that the maximum opening comes earlier in the stroke and that the opening at the commencement of the stroke (the lead) is greater. If the lap is increased to offset this change of lead the port opening will be decreased.

Strength of Boiler Plate and Joint

(a) What is the percentage of efficiency of the joint in a boiler having a longitudinal lap joint, double-riveted, the thickness of plate being ⅜ inch, tensile strength 60,000 pounds, diameter of rivets ¾ inch, pitch 2½ inches, and shearing strength of rivets 42,000 pounds?

(b) Is the formula for efficiency of the plate in the joint,

$$\frac{P-d}{p},$$

where P = pitch and d = diameter of rivet hole, suitable for butt-strapped joints?

L. W. C.

(a) In a perfect boiler joint the shearing strength of the rivets should be equal to the strength of the plate between the rivets.

(b) The formula given is correct for all forms of joint and gives the strength of the punched plate as compared with the whole plate. With a joint of the dimensions given, the efficiency of the plate would be 70 per cent. The strength of the rivets is slightly less, but the friction of the plates held in close contact by the rivets would probably make the rivets the stronger part of the joint.

Stress on Longitudinal Seam

Prove that the stress on a longitudinal seam is equal to twice the stress on a circumferential seam.

J. B.

The force tending to pull a cylinder apart endwise is the pressure per square inch multiplied by the number of square inches in the head. This area is

$$\frac{\text{diameter}^2 \times 3.1416}{4},$$

and the force tending to produce rupture endwise is

$$\frac{\text{pressure} \times \text{diameter}^2 \times 3.1416}{4}$$

To resist this there is a ring of metal, the cross-section of which is the product of the thickness by the circumference or

$$\text{diameter} \times 3.1416 \times \text{thickness.}$$

Then the strain per unit area of metal is the force divided by the cross section of the metal to be pulled apart or

$$\frac{\text{pressure} \times \text{diameter}}{4 \times \text{thickness}}.$$

If we imagine a ring in the central portion of the boiler where it receives little or no support from the heads, the force tending to rupture the ring will be the product of its diameter, its length and the pressure per unit of area. The metal which would have to be separated to let the ring break in two would be twice the length multiplied by the thickness. The strain per unit of resisting section would be

$$\frac{\text{diameter} \times \text{length} \times \text{pressure}}{2 \times \text{length} \times \text{thickness}} =$$

$$\frac{\text{pressure} \times \text{diameter}}{2 \times \text{thickness}},$$

which is twice the strain found above as existing on the circumferential section.

Newark Engineers Hold a Smoker

Newark Association No. 3, N. A. S E., of New Jersey, held a smoker Monday evening, October 5. The hall was well filled with members and friends, among them being many prominent engineers. A good entertainment was furnished by Herbert Self, of the Keystone Lubricating Company, Joseph McKenna, William Murray, Charles Thompson, of Jenkins Brothers, and John W. Armour, of POWER AND THE ENGINEER. During the evening, Past National President Joseph F. Carney and National Vice-President William J. Reynolds made brief addresses. Refreshments were served.

Gerald Stoney, in a paper upon "Recent Advances in Steam Turbines," presented to the British Association, says that "Eight years ago the largest steam turbine made, which was considered an immense machine at the time, was for only 1000 kilowatts, and now there are large numbers ranging from 5000 to 8000 kilowatts, running and under consideration." He evidently has not heard of the 14,000-kilowatt machines which we are building in America.

The combined councils of the Universal Craftsmen of the metropolitan district, Newark and Paterson, N. J., will hold an entertainment and ball October 23, at Lexington opera house, New York City.

Seventy pounds, absolute, steam pressure will flow through an opening 1 inch square into the atmosphere at the rate of 1 pound per second.

On turning the current off an arc lamp, if the lower carbon stays red the longer the lamp is burning upside down and the wires should be reversed.

One pound of fuel oil (19,000 B.t.u.) will evaporate 14 pounds or more of water.

Business Items

The Engineering and Combustion Company, 143 Liberty street, New York, reports that the outlook for the closing of 1908's business on "safety" water-tube boilers, "Universal" chain-grate stokers, "Ideal" automatic pump governors and semi-metallic packing is far beyond its expectations.

For the new terminal power station of the Pennsylvania Railroad Company, West Thirty-first street, New York, two special 70-inch "Sirocco" turbine fans will be installed in connection with Neemes grates. These fans deliver 82,000 cubic feet of air per minute against a pressure of 2½ inches water gage at 290 revolutions per minute. The fans are of single-inlet type and are directly-connected to horizontal engines.

Hartley, Iowa, has awarded a contract to the Minneapolis Steel and Machinery Company for an 80-horse power Muenzel producer gas engine and suction gas producer for its municipal electric-light plant, for which bids were received on September 24. This company has also received a contract from the Hubbard & Palmer Company, of Mankota, Minn., for a 10x30-inch Twin City Corliss engine, a 60-inch by 16-foot horizontal return-tubular boiler, a feed-water heater and purifier and a boiler-feed pump, etc., for its new cleaning house and elevator at Kasota, Minn.

The Bruce-Meriam-Abbott Company, Cleveland, Ohio, was recently awarded the contract from the state of Pennsylvania for two 125-brake horsepower vertical four-cylinder natural gas engines, direct-connected by means of their flexible coupling to two 75-kilowatt direct-current generators, switchboard, etc., for the Pennsylvania Reform School, at Morganza, Penn.; also, one 55-brake horsepower vertical two-cylinder gas engine for the R. J. Christy Company, of Fremont, Ohio, and one 35-brake horsepower vertical two-cylinder gas engine for the St. Ann's Church, Buffalo, N. Y. They advise us that they find business is picking up very rapidly.

The Ohio Brick Company, Toledo, Ohio, has been using Buckeye boiler skimmers in its boilers and writes to the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio, as follows: "The two skimmers placed in our boilers about three months ago are giving entire satisfaction; in fact, doing everything, if not more, that you claim for them. As per your instructions when skimmers were installed, we did not open the boilers for four weeks, at which time we found that considerable scale had dropped from the tubes and shell to the bottom of the boiler. From the experience we have had we believe the skimmer will prove a saver of fuel, as well as minor boiler repairs."

Greene, Tweed & Company, 109 Duane street, New York, have received a letter from Gordon M. Mather, president of the Arctic Ice Machine Company, of Canton, Ohio, regarding the equipping of its line of ice-making machinery with the "Rochester" automatic lubricator. The letter says, in part: "You may be interested to know that we have used quite extensively during the past season your latest improved 'Rochester' automatic lubricators for supplying oil to ammonia compressor stuffing boxes, which is most difficult to do, and not in a single instance have we had a complaint, but, on the contrary, our customers have frequently spoken well of the lubricators, and we must conclude that what is satisfactory to them should be, and is, satisfactory to us. We have accordingly made arrangements to equip our entire line of ice-making machinery for the coming season with the 'Rochester.'"

New Equipment

City of Elsberry, Mo., has voted bonds for construction of electric lighting plant.

The Mansfield (Ohio) Railway, Light and Power Company will double its output.

The Auburn (N. Y.) Light, Heat and Power Company will double the output at its plant.

The city of Sausalito, Cal., has voted to issue $100,000 bonds to construct water-works.

The city of Palmetto, Fla., will establish a water-works system. E. T. Wilson, mayor.

The Reading (Penn.) Power Company will build a new plant at a cost of $1,500,000, it is said.

A new cold-storage building is being erected by the Nuckolls Packing Company, Pueblo, Colo.

The city of Luverne, Ala., has voted bonds for the construction of water-works and sewerage system.

The Oriental Rug Company, Martinsburg, W. Va., will build a mill. Electric power will be used.

The Brooklyn Heights Railroad Company, Brooklyn, N. Y., will erect a new substation to cost $65,000.

It is reported that the Adler Packing Company, Milwaukee, Wis., contemplates establishing a packing plant in Oklahoma City to cost about $250,000.

The Capital Traction Company, Washington, D. C., has awarded contract for the construction of a new substation.

It is reported that the Magazine (Ark.) Gin and Grist Company is planning to install an electric lighting system.

The Morgantown (Ind.) Light and Power Company, recently incorporated, will shortly put up a plant, it is said.

The Seguin (Texas) Electric Light and Power Company, it is said, contemplates rebuilding its hydro-electric plant.

The City Council, Havana, Ill., is said to be considering the question of establishing a municipal electric-light plant.

The City Council, of Bryan, Texas, is considering the question of establishing a municipal electric-light plant.

The citizens of Elsberry, Mo., have voted to issue $10,000 bonds for establishing a municipal electric-light plant.

A new factory building and power house will be erected for the Brighton Worsted Company, Philadelphia, Penn.

The Cincinnati (Ohio) Electric Light and Power Company will erect a new boiler plant at its East End power house.

The city of Great Falls, Mont., is said to be contemplating the purchase of a new pump of 2,500,000 gallons capacity.

The Beebe (Ark.) Light and Power Company has been incorporated and will establish an electric-light plant. J. S. Smith, president.

The Cataract Power and Conduit Company, Buffalo, N. Y., will receive $120,000 proceeds to be used for extending and improving plant.

The Lawton Mills Company, Plainfield, Conn., is having a new three-story building erected, which, with equipment, will cost over $250,000.

Plans are under consideration for the construction of a power plant for lighting and heating the city hall and court house at Baltimore, Md.

Charles Phelps and others have been granted a franchise by the Village Council, Jefferson, Ohio, to construct and operate an electric-light plant.

Plans are being made for a central heating and lighting plant for the Drury College buildings at Springfield, Mo. This will cost about $20,000.

The citizens of Sherman, Texas, voted in favor of issuing $14,000 bonds for the construction of an electric-light plant and $16,000 for water-works.

The Durham Cotton Manufacturing Company, East Durham, N. C., is preparing to install electrical equipment. About $75,000 will be expended.

Bids will be received until October 19 for the construction of water-works and sewerage system at Oakland, Md. Penniman & Farley, Baltimore, are engineers.

The city of Wellston, Okla., contemplates voting on bond issue for construction of water works. J. H. Kenney and T. V. Weathers are on the committee.

The finance committee of the council, Milwaukee, Wis., has recommended the erection of a municipal electric-light plant, for which over $200,000 is available.

St. Matthews Ice and Cold Storage Company, St. Matthews, Ky., has been incorporated with $30,000 capital. Incorporators, N. A. Hardin, W. N. Arterburn and others.

The American Special Pop Safety Valve

SIMPLICITY
QUALITY
RELIABILITY
SAFETY
DURABILITY

The necessity for equipping boilers with AMERICAN "SPECIAL" POP SAFETY VALVES is recognized by leading engineers.

¶ Their use is the best insurance you can have against costly and damaging explosions.

¶ Their durability and utility have been demonstrated by many years of hard and constant service.

¶ They are the most accurate, prompt and efficient safety valves in existence, and relieve with the least amount of waste.

¶ They automatically prevent excess pressure. Once set at the limit of pressure required, they can be depended on to fully relieve your boilers of all excess pressure.

¶ They are extremely simple in construction and like all other "AMERICAN" products, fully guaranteed.

¶ They have greater capacity for relief than any other safety valve in existence.

Circular 1-D contains full details.

The American Steam Gauge & Valve Mfg. Co.,

208-220 Camden Street, Boston, Mass.

New York, 26 Cortlandt St. Atlanta, 835 Equitable Bldg. Chicago, 7-9 So. Jefferson St.

Pittsburg, Frick Building Annex. San Francisco, 247 Pine Street.
Montreal, 444 St. James Street. Los Angeles, 213 So. Los Angeles Street.

When ordering gauges, valves, indicators, and kindred appliances for governing, indicating, measuring, recording and controlling steam, air, gas, oil, ammonia and all other pressures, be sure to specify those manufactured by us. Your interests can be best served by the protection they afford.

The W. F. Lyons Ice and Power Company has been incorporated at Kansas City, Mo., with $150,000 capital. W. F. Lyons, A. A. McDonough and Vernon Greene, incorporators.

The Johnstown and Gallitzin Street Railway has been formed to build an electric railway from Johnstown to Gallitzin, Penn. Wallace Sherbine, Wilmore, Penn., is president.

Bids will be received until 3 p.m. October 14 by the State Commission in Lunacy, Albany, for the extension of the water supply system at the State Hospital, Kings Park, N. Y.

The Interstate Railway and Power Company of Kansas City, Mo., has been organized to build and operate electric railways. William Kenefick, Bryant building, Kansas City, is interested.

The citizens of Ellis, Kan., will vote on the question of establishing an electric-light plant and water-works system. W. K. Palmer Company, Dwight building, Kansas City, Mo., will prepare plans.

The Georgia Power Company, Gainesville, Ga., has been incorporated with $1,500,000 capital by G. H. Prior, James A. Rudolph, of Gainesville, and others, to develop water-powers, operate electric plants, etc.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m. October 26 for piston pump, generators and engines, electrical supplies, babbitt metal, water gages, gage cocks, grease cups, etc., as per Circular No. 472.

The Valparaiso & Northern Railway Company, Valparaiso, Ind., has been incorporated to construct and operate street and interurban railways. Headquarters will be Valparaiso. Directors, George G. Pfleger, L. E. Woodward, D. R. Chase, of Chicago, and others.

City of Brownwood, Texas, will open bids on October 15 for machinery for a water-works pumping station, including a 1,500,000 gallon single-acting-belt driven triplex power pump and 100-horsepower producer gas engine. Superintendent of water works should be addressed.

The Isthmian Canal Commission, Washington, D. C., will receive bids up to 10:30 a.m. October 22 for oil pumps, horizontal plunger pumps, duplex vertical feed pumps, duplex horizontal feed pumps, washers, valves, cocks, boiler tubes, packing, etc., as per Circular No. 471.

New Catalogs

The McNaughton Foundry, Charlotte, Mich. Circular. Sectional grate bar. Illustrated.

The Hill Clutch Company, Cleveland, Ohio. Catalog. Collar oiling bearings. Illustrated, 40 pages, 5½x8 inches.

Sullivan Engineering Company, Poughkeepsie, N. Y. Catalog. Sullivan self-centering piston. Illustrated, 28 pages, 5½x7 inches.

Hancock Manufacturing Company, Charlotte, Mich. Catalog. Unions, pipe fittings, grease cups, etc. Illustrated, 6x9 inches.

Graphite Lubricating Company, Bound Brook, N. J. Catalog. Graphite and bronze bearings, bushings, washers. Illustrated, 6x9½ inches.

The Russell Engine Company, Massillon, Ohio. Catalog. Massillon feed water heater, purifier and oil extractor. Illustrtaed, 7½x11 inches.

The Jeffrey Manufacturing Company, Columbus, Ohio. Bulletin No. 13. Electric locomotives for industrial haulage. Illustrated, 32 pages, 8x10 inches.

The Consolidated Supply Company, 321 Dearborn street, Chicago, Ill. Loose leaf catalog No. 15. General railway and mill supplies, electric railway and mining supplies. Illustrated, 6½x9 inches.

Ingersoll-Rand Company, 11 Broadway, New York. Catalog No. EE-36. Small power driven air compressors. Illustrated, 50 pages, 6x9 inches. Pamphlet 74-B. Pneumatic pumping systems. Illustrated, 24 pages, 3½x6 inches.

Reeves Pulley Co., Columbus, Ohio. Catalog T-15. Variable speed transmission. Illustrated, 60 pages, 6x9 inches. Catalog. Wood split pulley. Illustrated, 32 pages, 5½x7½ inches. Catalog. Wood split pulley clutch. Illustrated, 24 pages, 3x6 inches.

General Electric Company, Schenectady, N. Y. Bulletin No. 4616. High-voltage type H transformers. Illustrated, 8 pages, 8x10½ inches. Bulletin No. 4618, belt-driven alternators, form PB. Illustrated, 4 pages, 8x10½ inches. Bulletin No. 4622. Polyphase maximum watt demand indicator, type W. Illustrated, 8 pages, 8x10½ inches. Bulletin No. 4619. Steady vs. unsteady voltage. Illustrated, 8 pages, 8x10½ inches.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

WANTED—Engineer, a sober, industrious man familiar with engines, boilers and generators in 2500 h.p. plant. Good references required. The Helderberg Cement Co., Howes Cave, N. Y.

WANTED—Chief engineer for combination hydraulic and steam power railway and lighting plant of 5,000 h.p. capacity. Must be thoroughly experienced. Address Box 47, POWER, giving full references.

HEAD FOREMAN WANTED, capable of firing Murphy automatic stokers attached to B. & W. boilers and who can give maximum results. Wages $2.75 per twelve-hour shift. Apply Tennessee Copper Co., Copperhill, Tenn.

ENGINEERS—Write to me about an entirely new appliance. For demonstration a limited number will be furnished without charge. Box 48, POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

CHIEF ENGINEER of large industrial plant desires change; active and alive, an expert with indicators and testing apparatus, can keep operating expenses at proper figures. Box 27, POWER.

WITH SEVEN YEARS' experience from shop to electrical engineer in charge of machinery and equipment of a railway light and power system, graduate mechanical engineer desires a change. Box 40, POWER.

POSITION WANTED as chief engineer; experienced with all kinds of engines, steam turbines, a.c. and d.c. generators, motors and switchboards, boilers and pumps; I can get results and furnish the references; have been seventeen years in the mechanical and engineering business Box 9, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

STIRLING BOILER TUBES, cracking off can stop at once or no pay. Wm. Fulton Engineering Co., office, 28 N. Canal St., Dayton, Ohio.

WANTED—A large pumping station for pumping natural gas. Inquire Pittsburgh Plate Glass Company, Room 1624, Frick Building, Pittsburg, Pennsylvania.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

MECHANICAL ENGINEER, technical graduate, manufacturing and sales experience East and West, would be glad to hear from engineers or manufacturers wishing representation in the Northwest Box 49, POWER.

WANTED—High-grade line of power and steam specialties, exclusive agency on commission and guarantee; western Pennsylvania, Ohio, West Virginia; wide experience; large clientage, ample reference. "Results," POWER.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—Electric light plant, growing town; 700 lights now in use. Price $6000.00. Reasons for selling, other business. Address Box 50, Giddings, Texas.

COMPLETE steam engineering course in I. C. S., brand new. Cost $75.00. will sell at once for $40.00 cash. A bargain. Write me. Box L., Valley Falls, R. I.

FOR SALE—One 24x48 Fraser & Chalmer Corliss engine in good running order. We invite inspection at our plant, where engine can be seen under full working conditions. Delivery during December. Carr, Ryder & Adams Co., Dubuque, Iowa.

150 HORSE-POWER tandem compound Corliss engine, in good order; 16-ft. wheel; 24-in. face. F. W. Iredell, 11 Broadway, New York.

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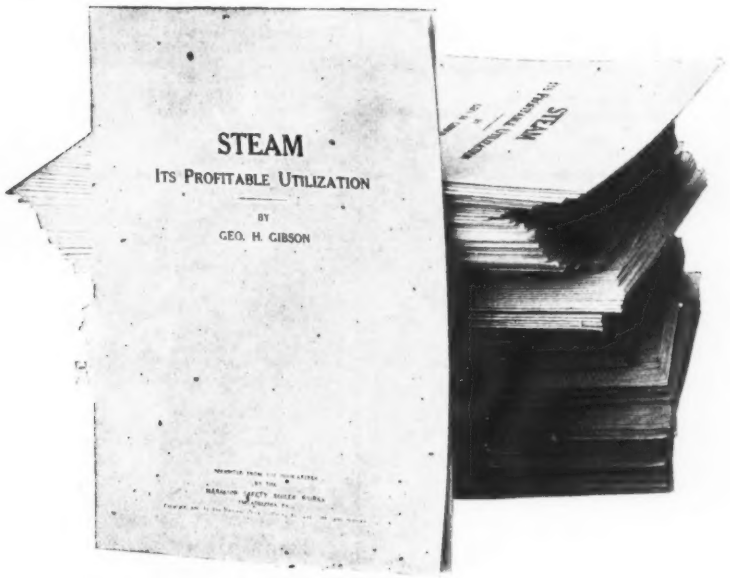

Some people get full value out of their exhaust steam---

DO YOU?

WE have a pamphlet - a little treatise reprinted from one of the magazines (you can have a copy for the asking) which will probably interest you, for it explains, or shows by drawings, some of the ways of utilizing exhaust steam for heating water for commercial purposes, as in textile and paper mills, leather factories, laundries, railroad roadhouses, etc.; how to heat the feed water when the main engine is run condensing.

You can get a good deal more out of a Cochrane Heater than simply heating the boiler feed supply, for these heaters perform the functions of muffle tank, return tank, water purifier, raw water regulator, pump governor, skimming tank, oil separator and feed water filter. Then you can count upon the Cochrane Oil Separator to protect your heating or drying systems from oil so you can safely utilize the condensed returns and the same efficiency which these Oil Separators give (more than 8,000,000 H.P. of boilers are being protected by Cochranes) is found in the Cochrane Steam and the Cochrane Receiver Separator. Lots of Steam Separators take out some water, but with the Cochranes you can count on taking out practically all water entrained in the steam—which means engine efficiency, lower cost for lubricating and protection always.

But that new heater which you will need shortly—that interests us because we know we can interest you if you will give us half a chance.

SO WRITE.

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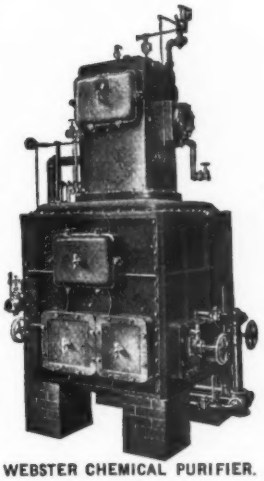

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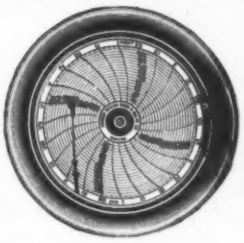

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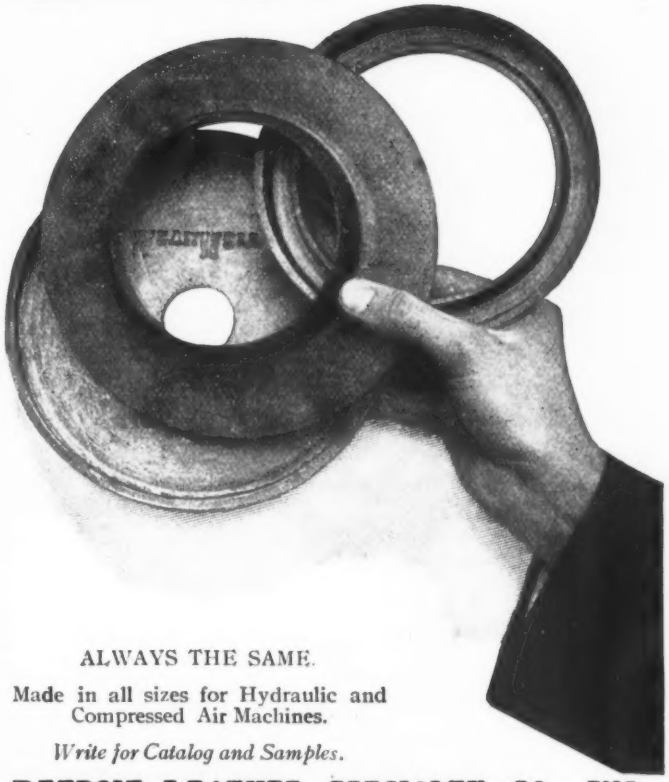

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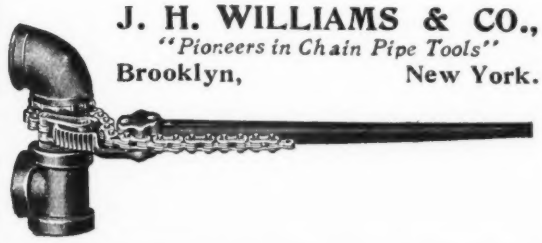

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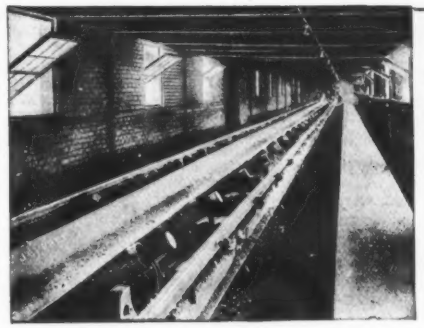

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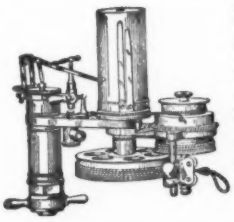

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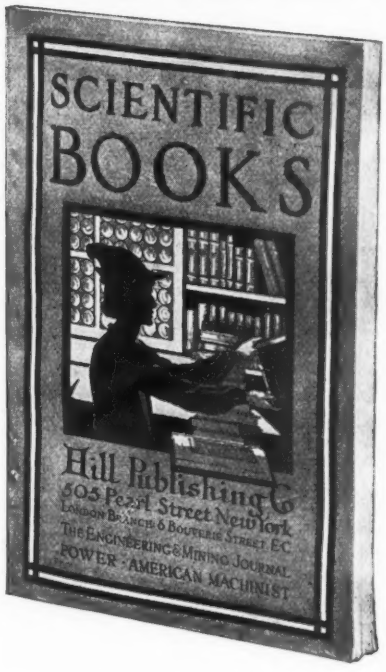

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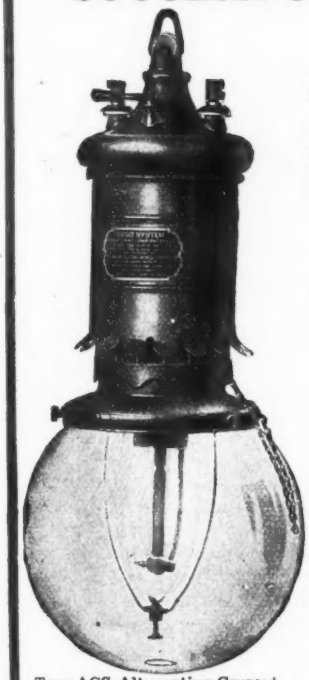

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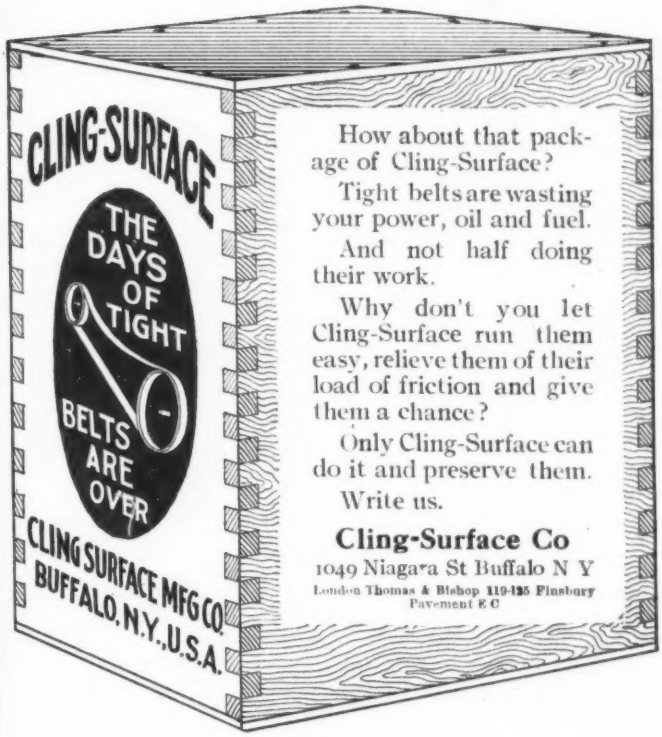

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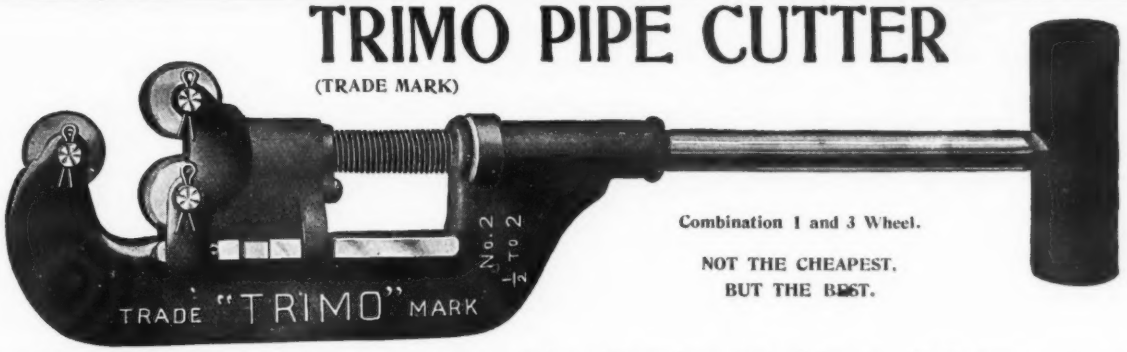

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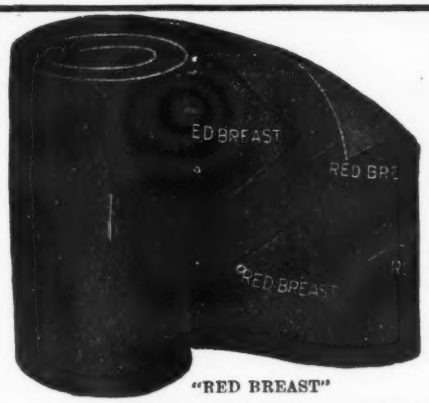

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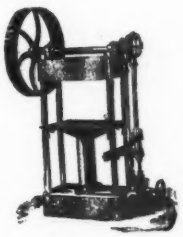

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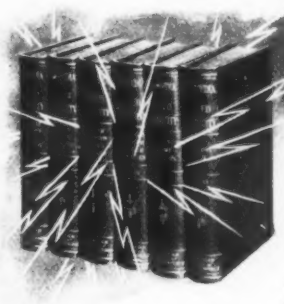

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Power, 10-13-08.

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The Rubber core is made of an oil and heat resisting compound, wrapped with a well frictioned Duck, with an outer cover of fine asbestos, lubricated by our secret process.

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Is without doubt the toughest and most durable High Pressure Sheet Packing on the market. It will stand the highest pressure and extreme heat, making a tight joint when used for Steam, Air, Hot or Cold Water.

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Although "Eureka" costs a third less than other first class packings it has proved its ability to do better work and outlast them in severe service. For rods that are scored or out of line there is absolutely no equal to Eureka Gum Core. It's made on correct principles, by expert workmen, and only the purest, finest materials are used. Give "Eureka" a trial.

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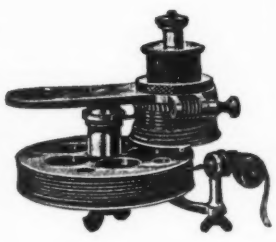

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is very different from the complicated combinations of rings and springs which heretofore have been the only refuge from short lived fibre packings. AMBEST is composed of long pliable filaments of a secret non-friction metal, lubricated by our special high test lubricating compound. *It's all alike*, there's only one kind of AMBEST and the largest piston rod or the smallest valve stem may be packed equally well from the same can. No chance for waste. AMBEST will not fuse under temperatures corresponding to 1000 lbs. steam pressure, and it cannot under any circumstances cut or score a rod. It is as frictionless as oil. With slight additions at rare intervals to compensate for wear it will last forever, and should it be desired to place it in another stuffing box it may be removed quickly and easily. In short, it is a *simple*, *effective* and *permanent* packing for *steam*, *water* or *ammonia*, and you will be interested in our free booklet. Write for it.

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Gentlemen:—You may send me, free of all charge, a sample of AMBEST Metallic Packing.

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Packing now in use.....

Power, Oct., '08

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That's the candid opinion of the best authorities regarding Goetze's Elastic Copper Gaskets.

Try them on some of those "impossible" joints where every ordinary packing has failed. Try them on raw and unmachined surfaces. We'll leave the test in your hands. Once in, Goetze's Gaskets will hold—*hold*—HOLD. Can be used over and over.

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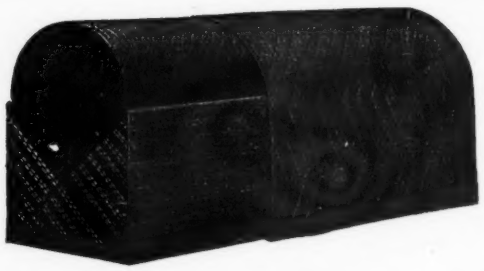

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IT WORKS
LIKE THE UNIVERSAL CHUCK

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Will tell you it has the

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A 14 x 28 hanger, like cut herewith, but in colors, free to any engineer upon request.

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"The Big Three."

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Belmont Expansion No. 1.—For ammonia and for steam up to 125 lbs. pressure. The two wedges are independently movable within the casing. By pulling one forward an inch or two, and pushing the other back an equal distance, the break, when the ring is closed, is divided into three parts occurring at different points around the circumference. This feature enables one ring to hold steam or ammonia as well as three rings of any other packing, and makes it invaluable for shallow stuffing boxes. Write for booklet A.

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A full line of other packings for every known purpose. Large general catalogue free on request. Sample ring of any packing free. Fill in coupon stating kind wanted.

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No. engines..... No. pumps.... No. boilers....
High or low pressure .....
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Material, Workmanship And Machinery Perfected In Long Experience And At Great Expense

These features are responsible for the perfection of Johnson Packings.

We make a greater variety of packings than any other manufacturer and each is the best of its kind.

Catalog on request.

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TRADE MARK. REG. IN U. S. PAT. OFF.

All Goods Stamped with the VANDA TRADE-MARK will fulfill the claims we make for them.

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THIS PACKING IS THE PIONEER OF ALL COMPOSITION PACKINGS, AND IMITATORS ARE APPEARING IN GREAT NUMBERS. WE THEREFORE, WOULD ESPECIALLY CALL YOUR ATTENTION TO OUR

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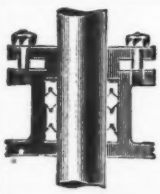

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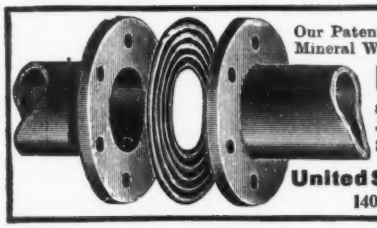

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The Packing for Water Works, Stern Pipes of Propellors; Deep Mine Pumps, Air Drills, Ice Machines and all machinery using cold water.

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PLASTIC
METALLIC PACKING

For Steam, Water, Air, Gas, Hydraulic Machines, Valves, Etc.

Guaranteed to stand Steam Temperature up to 550° F. and Hydraulic Pressure to 5000 lbs. per square inch.

Highest Award World's Fair, St. Louis.

Send for **FREE SAMPLE** and particulars.

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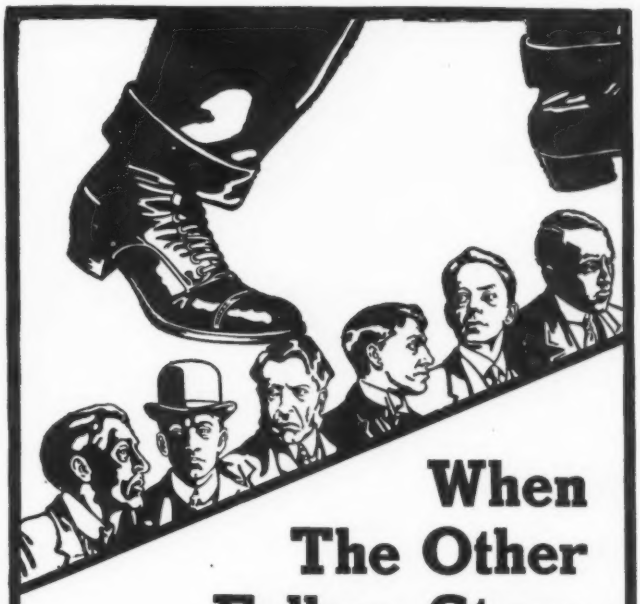

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Yes, it does jar you to have some other fellow step over your head and take possession of the job you've had your eyes on for some time—to say nothing of money that goes with it.

But why does this happen?

A little thinking brings you face to face with the undeniable fact that **training** is responsible for it—that while you were **waiting** for opportunity, trusting to luck for promotion, the other chap was **making** his opportunities by preparing himself for positions ahead.

To advance you must have the practical training that makes you an expert. No man can expect to get a higher position if he has not the ability to competently hold that position.

I. C. S. Trained Men Win

The I. C. S. brings a six-million-dollar equipment and an experience of nearly 17 years in the sole business of salary-raising training to the personal advancement of every one of its students. It assists these men in their own homes, in their spare time, and at a cost arranged to suit their own individual circumstances. It overcomes all obstacles of lack of time, money, or education, and secures for poorly paid wage earners such advancement as they never even hoped for before. What the I. C. S. has done for thousands of other men it can do for **YOU.**

Without any cost to you the I. C. S. will tell how **you** can get in line for promotion. Simply mark the coupon below and mail it. **Initiative wins—mark and mail this coupon NOW.**

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Bridge Engineer	Marine Engineer	Sheet-Metal Draft.
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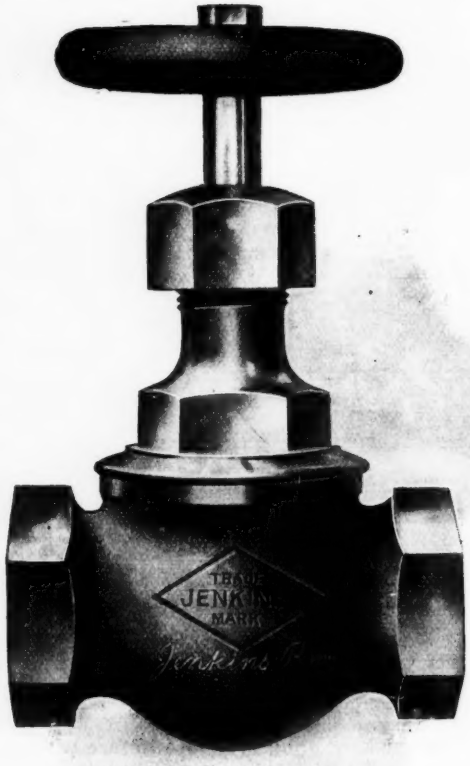

AROUND the globe, in every country sufficiently civilized to have achieved the valve using stage, JENKINS BROS. VALVES are known and used. An article to travel so far afield must be superlatively good. JENKINS BROS. VALVES travel the world over on merit alone; and whenever they are once used the use increases, as the constantly enlarging demand for them proves. There are other valves—and many of them are good, but experienced engineers select the best—they order JENKINS BROS., which cost no more than those claimed "just as good." Owners of steam plants can save expense, and engineers trouble and vexation by using JENKINS BROS. VALVES—the best.

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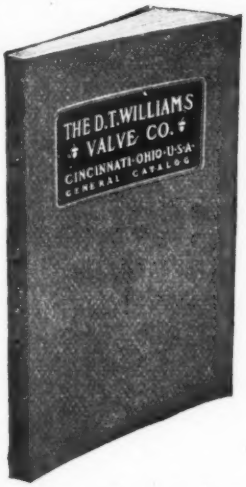
This Book Should Be Your Guide.



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904-910 Broadway, - CINCINNATI, OHIO
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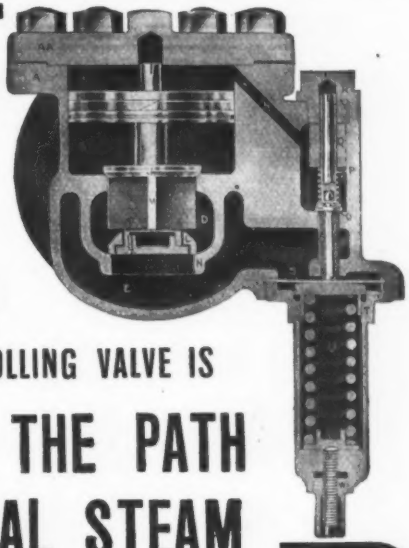
COLLIN STEAM PRESSURE REGULATING VALVE



THE CONTROLLING VALVE IS

OUT OF THE PATH OF INITIAL STEAM

This feature protects the controlling valve from scale and dirt and is only one of the many advantages possessed only by the Collin Valve.

Made in bronze from ¾ to 2½ inches and iron body, bronze lined, from 3 to 8 inches.

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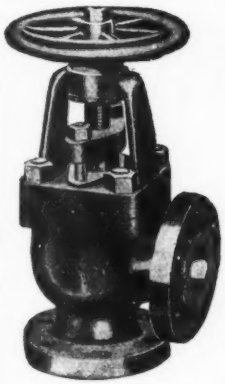

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EDWARD VALVE

For High Pressures, Superheated Steam and Water.

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Oil Dash Pots for Corliss Engines, Gas and Gasoline Engines.

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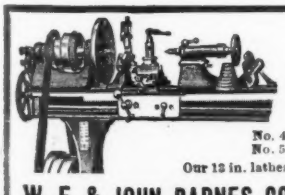
CAN YOU TURN A KEY?

If so, then you can operate a Mason Reducing Valve. Turn it to any desired pressure and slip the key on your key-chain. The "Mason" will be tamper-proof. Write!

The Mason Regulator Co., Boston, Mass.



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LATHES

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9 in. to 13 in. Swing.

No. 4½ Lathe, 9 in. x 25 in., List $ 75.00
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Our 13 in. lathes made 5 to 10 feet long. Send for lathe catalog.

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Is It Policy to Sacrifice The Harmony Of Your Entire Plant Through Careless Installation of Valves?

With wide-awake, progressive business men, **positively no!**

With such men no pipage equipment but the best will pass —**absolutely none but the best at the start!**

A plant equipped right at the start will remain right! A plant equipped right at the start will create safety and satisfaction to all concerned!

Every valve and every piece of pipage equipment made by us is not only right at the start, but IT'S RIGHT FOR ALL TIME! Tuyeres, Tuyere Cocks, Regulators, Traps, Etc., Etc. Send for Catalogue.

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Pittsburgh Iron Body Gate Valves

These valves are guaranteed to work under all pressures with less wear on the faces of the seats and discs than any other valve manufactured.

Those who desire a double gate will find their **ideal** in the "Pittsburgh." An adjustable wedge, guided by ribs cast in the body, prevents the disc from scraping its faces. Thousands are in use for steam, oil, gas, water, gasoline and alcohol, and we have never had a single complaint.

WE MANUFACTURE ALL KINDS OF VALVES AND FITTINGS. WRITE.

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DAVIS PRESSURE REGULATORS SAVE STEAM

PRESSURE REGULATOR

Do It Automatically

If you are using live steam for heating, drying, cooking or some other purpose at a pressure lower than that carried on the boiler, let the Davis Pressure Regulator make the reduction for you automatically.

This valve can be adjusted to deliver steam at just the pressure needed and it will maintain that pressure without fluctuations no matter how much the initial boiler pressure may vary.

Reducing steam by throttling through a cracked globe or gate valve is about as satisfactory as using saw dust for fuel. You may be able to get along after a fashion, but why not do it right—automatically.

If you are running your engine non-condensing a Davis Automatic Back Pressure Valve will enable you to make use of the exhaust steam instead of letting it go to waste.

Contrast this valve with its semi balanced disc, small weight and noiseless operation without any possibility of injury to the seats, with the old style single seated valve which pounds like a trip hammer and keeps you poor buying seats for it. Is there any comparison—would you choose the single seat?

Send for a complete catalog of Davis Valve Specialties. It is of interest to both owner and operator.

G. M. Davis Regulator Company,

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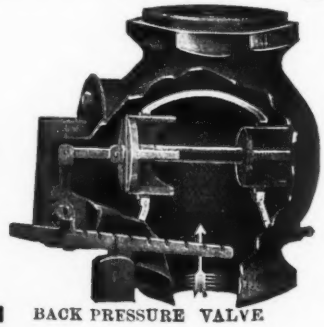
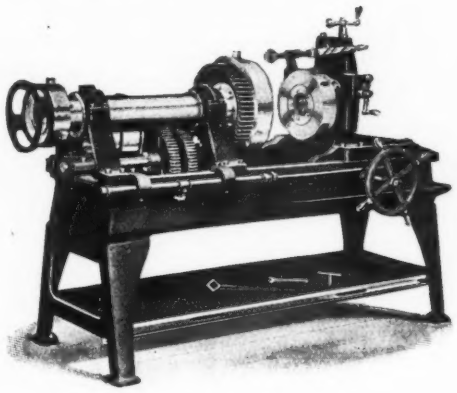


BACK PRESSURE VALVE



STEP

into most any shop where several makes of pipe machines are installed, and if any are in use, they are B. & K. The workman prefers to run the B. & K. machines because they are easy to operate and always make good threads.

Bignall & Keeler Mfg. Company
Edwardsville, Ill.

¶ When putting in a new valve, you turn it around and around until it is nearly up to the shoulder of thread on the pipe. You say to yourself, "it will go one more time"—and keep on turning. It goes part way then stops. You apply the wrench to bring the valve up where you want it. At the same time you have twisted the seat, and the new valve leaks badly.

You've done this trick yourself, time and again.

A few turns of the cutter with a

Dexter Valve Machine

will make these seats absolutely true and tight.

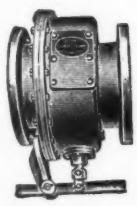
Catalog "P" illustrates these machines.

The Leavitt Machine Co.,
Orange, Mass., U. S. A.

FOSTER VALVES

A visit to any steam plant employing Foster Valve Specialties; a little observation on your part of the various good points about them will readily convince you of their true worth.

We show here a Foster relief or free exhaust valve. This valve gives instant relief to the exhaust in case of the failure of the condenser or loss of vacuum.



It is sensitive, noiseless and has no parts liable to be clogged or corroded.

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PERMANENTLY LEAKLESS JOINTS
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"BALLWOOD" Welded Flanges

They are made of the same grade metal as the pipe and are welded in such a way that they become integral parts of the pipe, expanding and contracting with it. *Circular* 104?

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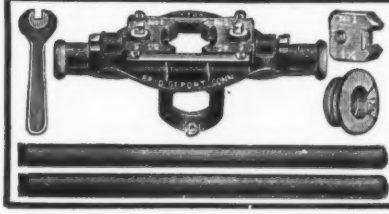
A quarter turn is all that is necessary to open or close a Homestead and it locks where you set it. Booklet?

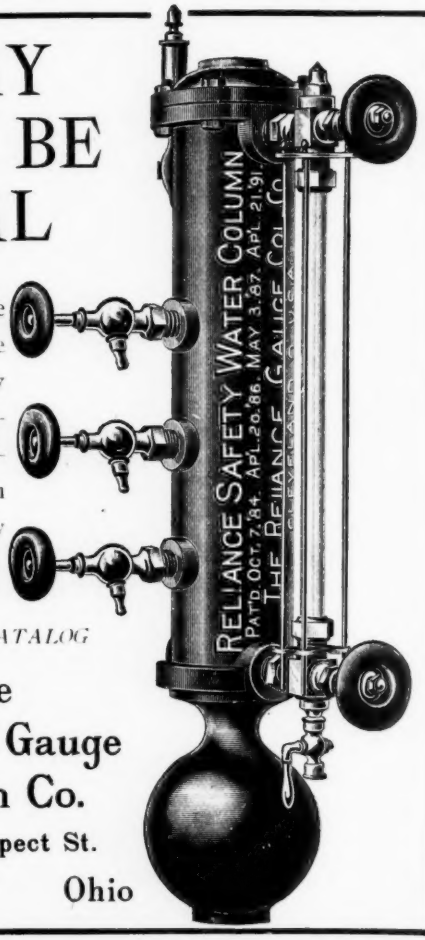
Homestead Valve Mfg. Co.
Brass Founders. **Pittsburg, Pa.**



STOCKS AND DIES
PIPE MACHINES,
PIPE CUTTERS,
VISES.

Manufactured by
The Armstrong Mfg. Co.
287 Knowlton St.,
BRIDGEPORT, CONN.

DELAY MAY BE FATAL



The Reliance Column is the only absolutely dependable device for preventing explosion due to unsteady water level.

ASK FOR CATALOG

The Reliance Gauge Column Co.

75 E. Prospect St.

Cleveland, Ohio

Don't Get Into Hot Water

if the gauge glass breaks.

Scalding water and hissing steam never did any body any good but the doctor.

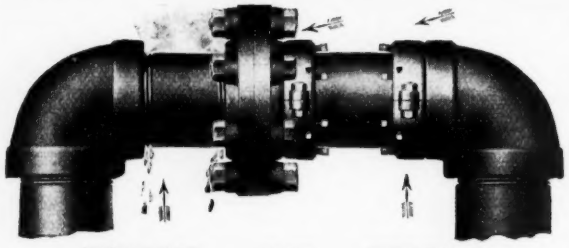
If you use the "P. B. H." Quick Closing Water Gauge, you can stand out of harm's way when the glass breaks and shut off the escaping steam and water by simply pulling a chain.

We'll *insure you* for 30 days by sending you a "P. B. H." for a *free* trial.

Circular?

THE PAUL B. HUYETTE CO., Inc.

2025 Betz Building, PHILADELPHIA



THIS OR THIS

Take your choice. If you have the Simplex Pipe Clamp you can stop the worst leaky joint and render it absolutely and permanently tight. This we *guarantee*. 30 days' free trial. Write.

THE SIMPLEX ENGINEERING CO.

316 Preston Street Philadelphia, Pa.

"KEWANEE UNIONS"

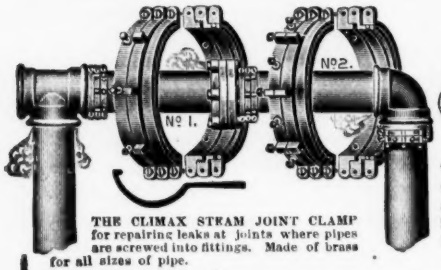
"M. & F."
Tested under water by compressed air.
No gaskets required.
Iron-to-brass contact.
Never corrode.

PATTERN
Self-seating ground ball joint.
No marred unions, trying to disconnect.
Easy connections.
Fewer joints.

NATIONAL TUBE CO., Pittsburg, Pa.

DISTRICT SALES OFFICES

Atlanta Denver New York Pittsburg St. Louis Salt Lake City
Chicago New Orleans Philadelphia Portland San Francisco Seattle



THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.

THE EMERGENCY PIPE CLAMP, for repairing splits and rust holes. Made of malleable iron from ⅛ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

Send for Catalog of

STEAM SPECIALTIES

JAMES McCREA & CO.,

MANUFACTURERS,

61 West Washington Street, Chicago.

What's Doing in Your Boiler?

If you don't know you are taking risks and wasting money. The Ashton Gage is the peep hole through which you can see what's doing.

Write for catalog.

THE ASHTON VALVE COMPANY, Boston, U.S.A.

NEW YORK St. John's House, London, Eng. CHICAGO

Automatic Valves Instantly Close When A Glass Breaks

This feature of the Stulp Water Gauge is worth many times its cost. Why take a chance of being scalded? **Special Price, $10.**

Buy the gauge that is approved by U. S. Government.

The Automatic Safety Water Gauge Co.,

Fred J. Stulp, Prop. **Muskegon, Mich.**

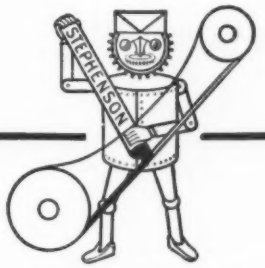
Adapted to the Measurement

of live or exhaust steam, water, air or other gases. This meter writes permanent reports which can be filed for future reference.

DETAILS?

G. C. ST. JOHN
140 Cedar Street
NEW YORK

The St. John Indicating and Recording Steam Meter



THE AFTER EFFECTS ARE PLEASANT

Don't waste good belts and lose valuable power. **STEPHENSON Bar Belt Dressings** contain no Rosin nor any other ingredients injurious to Belting. Our **RED Label** and **GREEN Label Brands** are two entirely different and distinct preparations. No one kind of Dressing is good for all Belts—you know that. **STEPHENSON Dressing** not only prevents slipping and gives full speed from slack belts, but **the after effects are pleasant**—it KEEPS those belts in good condition and greatly prolongs their life.

This means a saving in BELTING, which is an important item when figuring the year's expenses.

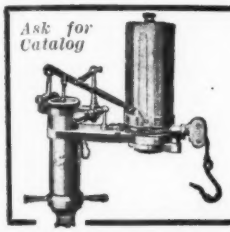
RED Label Brand for Leather belts;
GREEN Label for Rubber and Canvas.

Your protection against substitution is **The Man with the Cog-Wheel Face** on each Pound Stick.

Of Dealers everywhere, or

STEPHENSON MFG. CO.
ALBANY, N. Y

Ask for Catalog



You Can Save $50

have a better indicator than the most expensive, one that will last longer and give less trouble.

If you try a Trill at our expense you will prove our claims before you spend a cent.

Trill Indicator Co., Eagle Street, Corry, Pa.

RHOADS LEATHER BELTING

Handsome is as handsome does.

J.E. Rhoads & Sons

PHILADELPHIA 12 N. THIRD ST. NEW YORK 40 FULTON ST.
BOSTON
HAMBLET & HAYES CO. EASTERN AGENTS, 105-111 SUMMER ST.
FACTORY, WILMINGTON, DEL.

Belting Logic—If best Leather Belting costs per sq. ft. $1.00, best Rubber Belting 60c., and best Stitched Canvas Belting 40c., and with Leather showing 25% and Rubber 50% of the strength of **Best Stitched Canvas Belting,** wouldn't it be good policy for you as a practical man to investigate the merits of our product? Send for Book "C."

SAWYER BELTING COMPANY, **CLEVELAND, OHIO.**

Robins Laminated Leather Belting

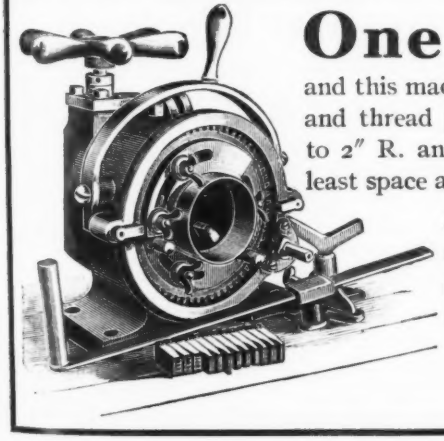
Is made continuous without laps, plies or cement. Guarantees an equal distribution of strength and an uninterrupted line of power transmission.

Write for circular No. 2.

ROBINS NEW CONVEYOR COMPANY

New York, 38 Wall Street — Factory, 168 Duane Street — Chicago, Old Colony Bldg.

SAGINAW MANUFACTURING CO.,
SAGINAW, MICH., U. S. A.
MANUFACTURERS OF
GILBERT WOOD SPLIT PULLEYS.
New York Branch, 88 Warren Street.
Chicago Branch, 32 South Canal Street.
Sales Agencies in all principal cities.
Cable Address, "Engrave" A. B. C. and Lieber's Code.



One Man

and this machine can cut and thread pipe from ¼" to 2" R. and L., in the least space and time.

Have the Circular?

The Curtis & Curtis Co.
85 Garden St., Bridgeport, Conn.

ONE MAN POWER

"TOLEDO NO. 3"

is all that this machine requires to thread pipe from 4½" to 8" inclusive.

The "Toledo" weighs but 155 lbs. and can be carried to the work, thus saving a great deal of time and labor. Write.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO.

SAVE POWER BELTING BEARINGS

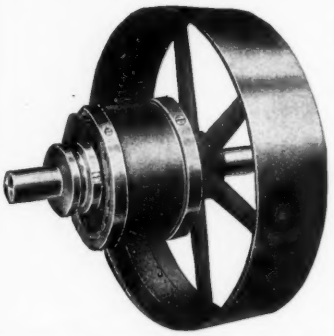
It will pay to use SHULTZ SABLE BELTS. They transmit from one-fourth to one-third more power, cost nothing for wasted power, time or repairs. We can show you SABLE belts that have worked steadily day in and day out for more than a quarter of a century, and are still good.

Send for a SABLE belt for 60 days' free trial and if it doesn't "make good" send it back at our expense. Write for our Belt Book.

SHULTZ BELTING CO.,
ST. LOUIS, MO.

NEW YORK BOSTON PHILADELPHIA

STARTS GRADUALLY

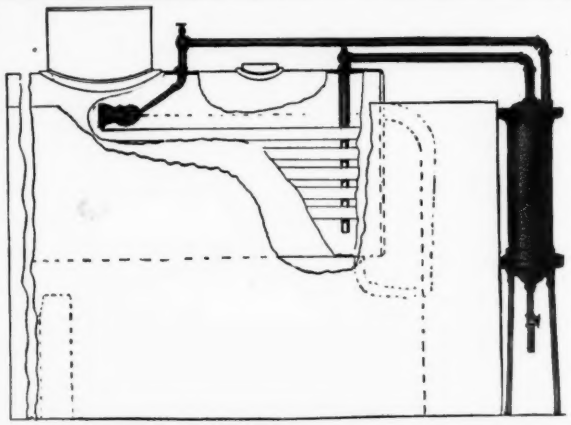


without shock or jar.

The Akron Friction Clutch is guaranteed to transmit its full rated power. If at any time the load exceeds H. P. of clutch, it will *slip*. The safest clutch made. Working parts run in oil.

CIRCULAR?

The Williams Foundry & Machine Co.,
AKRON, OHIO.
Successors to the Akron Clutch Co.



You Save a Big Sum By Skimming the Scum

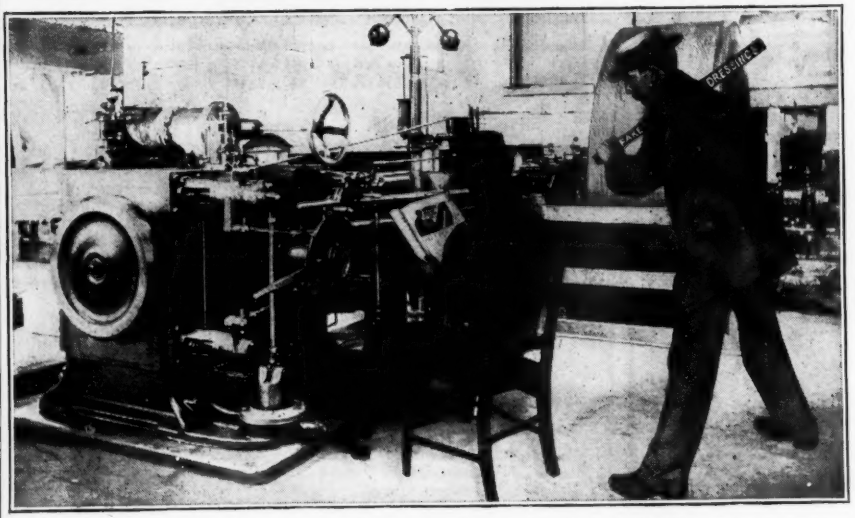
with a BUCKEYE BOILER SKIMMER. Boiler compounds and mechanical cleaners are a *continual expense*, but after you once place a "BUCKEYE" in your boiler, there's no need to spend another penny. It does its work mechanically and keeps your boiler free from scale by trapping the scale-forming impurities *before* they can do harm. 30 days' free trial. WRITE!

Buckeye Boiler Skimmer Co.,
SOUTH END, TOLEDO, OHIO.

OXoilOX

VIENNOT-PHILA

DON'T BE SAND-BAGGED



DON'T let some slick tongued fellow make you pay for ruining your own belts. **You know** that resin does your belts no good; you know that tallow and lard are not worth much for belt dressings; don't buy them then just because they are put up in an attractive package and labelled "Belt Dressing."

Get acquainted with **OXoilOX,** pure Neatsfoot Oil refined and improved so that it preserves and strengthens belts.

OXoilOX doesn't make belts sticky. It isn't a dope—it's a belt food, that keeps belts **soft** and **tough** and **clean.** Belts treated with **OXoilOX** cling to pulleys so closely that air is absolutely excluded, and the vacuum thus formed prevents slipping, and enables belts to **run slack** at full load.

Our booklet tells how **OXoilOX** was discovered—you'll be interested; mailed free on request.

A FREE SAMPLE

F. S. WALTON CO., Philadelphia, Pa.

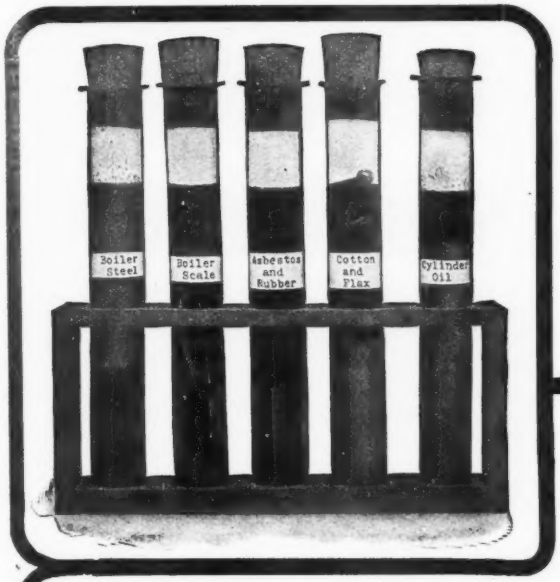
Gentlemen: Kindly send us, free of charge, a sample can of OXoilOX the Perfect Belt Dressing.

Name.....Address.....

Name of Firm.....Number of Belts.....Average Size.....

F. S. WALTON CO., Philadelphia, Pa.

Pressers and Refiners of all grades of Neatsfoot oil.



Isn't This Proof That Magic Boiler Compound Will Not Injure Boilers, Packings, Lubricants, Valves, Etc.?

Photograph shows samples of asbestos, rubber, cotton, flax, cylinder oil, boiler scale and boiler steel which have been in MAGIC BOILER COMPOUND *for more than a year*, without showing the slightest signs of deterioration. This is proof positive that MAGIC contains nothing injurious to the packing, lubricants, valves, etc., in a boiler. A careful analysis will prove further that MAGIC contains nothing that can affect the parts of a boiler or the product of a plant, as shown by copy of letter below.

But we do not ask you to take anybody's word for this. We will gladly send you enough MAGIC BOILER COMPOUND for a sixty days' trial, with the distinct understanding that it will cost you nothing if you do not find it exactly as claimed after a thorough examination and trial in your plant.

We also warrant MAGIC to remove all scale already formed in any boiler in any locality and to prevent more forming; to remove oil and grease; to stop minor leaks in a boiler; to stop pitting and galvanic action; and not to evaporate from the boiler or cause it to foam.

Do you know of any other boiler compound that is sold with such a strong warranty? When a manufacturer is willing to send out his product with the privilege of trying it without cost, provided it does not do all claimed, he must have *more than ordinary confidence* in his product. We have more than ordinary confidence in Magic, because we know that it can always be depended on to do as above claimed.

Why not at least give it a trial? You are taking no chances under our warranty.

Write Nearest Branch for Free Trial Offer and Booklet.

ZYMOTECHNIC INSTITUTE
SCHOOL OF BREWING

Chicago, June 13, 1905.

Messrs. John Callahan & Co.,
Seattle, Wash.

Gentlemen:-

In compliance with your request, we have made an examination of the sample of BOILER COMPOUND sent us recently, and find that the said Compound contains nothing injurious to iron and can be used with safety in any boilers connected with breweries, ice plants, etc., and without injury in any way to such articles as they manufacture.

Respectfully submitted,
ZYMOTECHNIC INSTITUTE,
J. E. Siebel, Ph. D., Director.

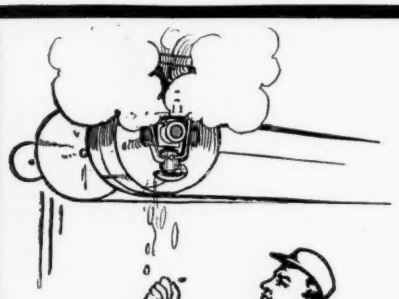
H. W. JOHNS-MANVILLE CO.

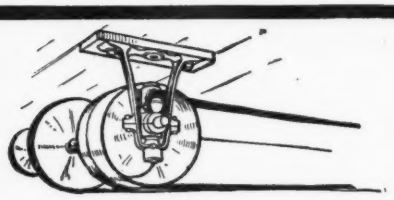
Manufacturers of Asbestos and Magnesia Products, Asbestos Roofings, Packings, Electrical Supplies, Etc.

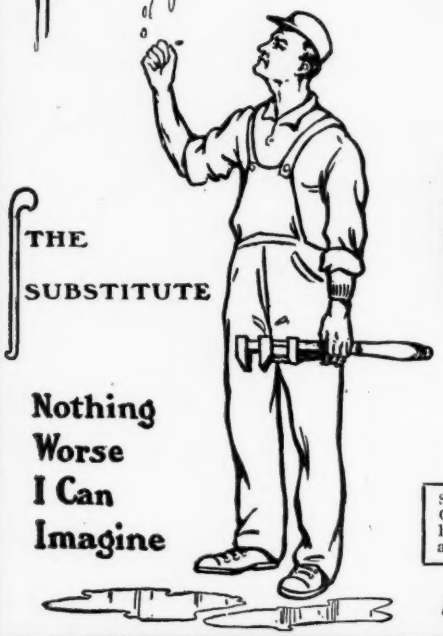
New York	St. Louis	Baltimore	Los Angeles
Milwaukee	Pittsburg	New Orleans	Seattle
Chicago	Cleveland	Kansas City	Dallas
Boston	Buffalo	Minneapolis	Toronto
Philadelphia	Detroit	San Francisco	London

THERE IS ONLY ONE

ALBANY GREASE







THE SUBSTITUTE

Nothing Worse I Can Imagine

The only Genuine ALBANY GREASE has this trade mark on every package. Look and ask for it.

Send for FREE sample cup and can of "Albany Grease," giving size of tap for cup, depth of oil hole from top of cap to journal, where to be used and firm's name.

MADE ONLY BY
ADAM COOK'S SONS,
313 WEST ST., NEW YORK.

NOTHING EASIER EZR I SEE IC

THE ONLY GENUINE.

GRAPHITIZE YOUR OIL

with Graphlio—The Crystalline Graphite. By so doing, you double the efficiency of the oil and save at least 45% in the amount of oil used. Write for Circulars.

WALTER D. CARPENTER & CO.,
39 CORTLANDT ST., NEW YORK.

Pure Water---No Scale

If you use Pyramid Boiler Compound. It takes all scale-forming impurities out of the water and insures full boiler capacity. Write us.

Binghamton Boiler Compound Co.,
BINGHAMTON, NEW YORK.
Los Angeles, Cal.; Seattle, Wash.; Portland, Oregon; Cincinnati, Ohio; Cleveland, Ohio; Providence, R. I. Syracuse, N. Y.; Scranton, Pa.; Louisville, Ky.; St. Louis, Mo.; Birmingham, Ala.

THE HAWK-EYE BOILER COMPOUND NEVER FAILED.

See our Advertisement in First Issue Every Month.

HAWK-EYE COMPOUND CO.,
303-304-305 Merrick Block, CHICAGO, ILL.

ELEPHANT BRAND

REG. U. S. PAT. OFF.

THE PHOSPHOR BRONZE SMELTING CO., Limited.
2200 WASHINGTON AVENUE, PHILADELPHIA, PA.
ELEPHANT BRAND *Phosphor Bronze*
INGOTS, CASTINGS, WIRE, RODS, SHEETS, Etc.
— DELTA METAL —
CASTINGS, STAMPINGS AND FORGINGS
ORIGINAL AND SOLE MAKERS IN THE U. S.

FIVE POUNDS OF SCALE PER HOUR

may easily collect in a 250 H. P. Boiler, or if running condensing, enough oil and grease from the condensation, though less in quantity, may become even a greater menace.

BIRD-ARCHER BOILER COMPOUNDS

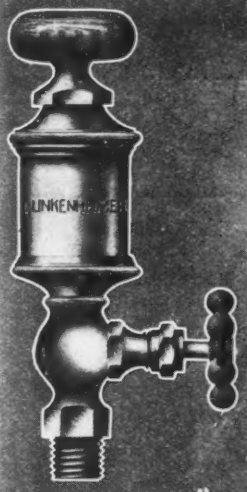
will not only prevent this matter from adhering to the heating surfaces, but actually pay big dividends by cutting scale prevention to the lowest possible cost, by keeping boiler capacity high and heating surfaces clean and by doing away with the delays and repair expenses which always result from scale formation.

Sold on a "NO CURE, NO PAY" basis.

WRITE FOR CATALOG.

THE BIRD-ARCHER CO., 90 WEST ST. NEW YORK
8

CYLINDER LUBRICATION



"PLAIN ENGINE"

is a subject that requires very careful consideration. That it has been given careful consideration can be vouched for by users of

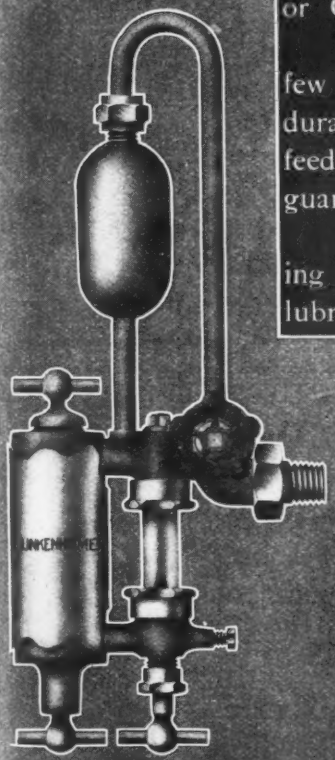
Lunkenheimer Cylinder Lubricators.

The line includes LUBRICATORS for AIR COMPRESSORS, STEAM, GAS or GASOLINE ENGINE CYLINDERS.

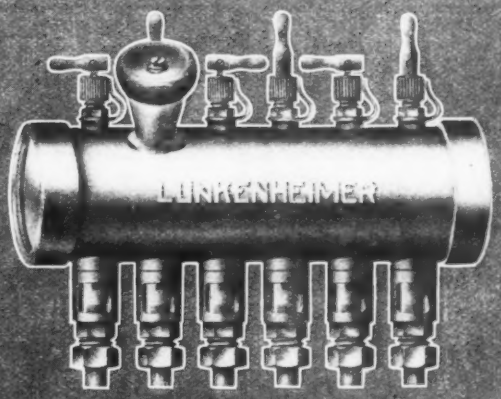
They are very neat in design, consist of few parts and are exceptionally strong and durable. A steady, positive and economical feed is insured, and perfect satisfaction is guaranteed.

Write for catalog illustrating and describing the most complete line of high grade lubricators made.

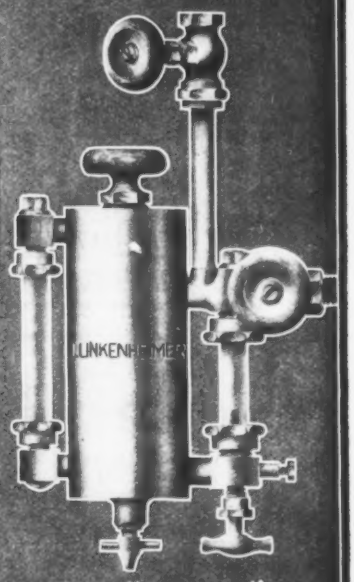
"VULCAN"



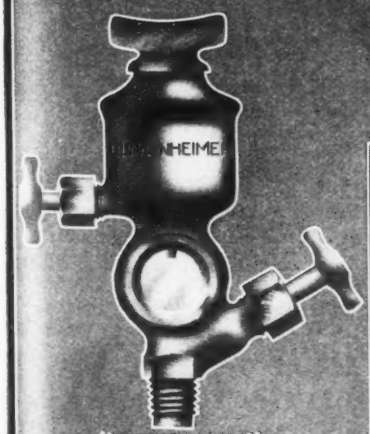
"JUNIOR"



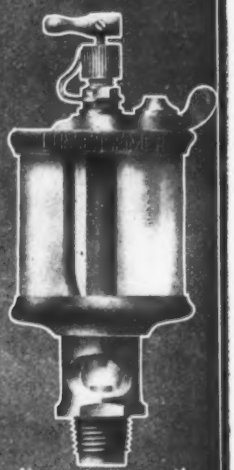
"MULTIPLE OILER"



"SENIOR"



"PREMIER"



"PARAGON"

The Lunkenheimer Company

Largest Manufacturers
of High Grade Engineering Specialties in the World
General Offices and Works, Cincinnati, Ohio, U.S.A.
New York, 66-68 Fulton St.
Branches: London, S. E. 35 Great Dover St.
Chicago, Lake and Dearborn Sts.

500

Detroit Improved Standard Lubricator

Some One

of our 337 different styles and sizes of sight-feed lubricators will fill any requirement you may have.

When ordering, insist on getting the genuine Detroit.

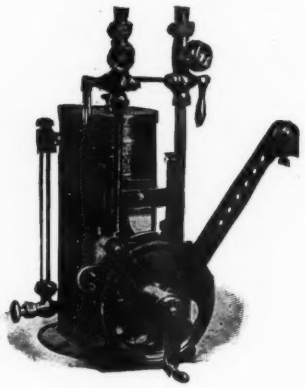
Write for a catalog of the most complete line of oiling devices for all purposes.

DETROIT LUBRICATOR COMPANY.
Detroit, U. S. A.

LATEST IMPROVED

ROCHESTER

Automatic Lubricators give "Perfect Force Feed Lubrication"



Send for Catalogue.

GREENE, TWEED & CO.,
109 Duane Street, New York.

Flake Graphite

Marked

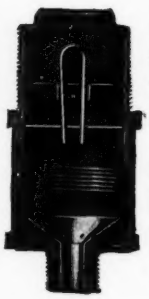
"DIXON"

Reduces All Friction

wherever this friction occurs. It prevents wearing on bearing and shaft no matter how high the speed. If you see the importance of better lubrication, drop us a line asking for a free sample to try. Specify Can 94-C.

JOSEPH DIXON CRUCIBLE CO.,
JERSEY CITY, N. J.

The "Philadelphia" Grease Cup



Automatic application of grease to the bearing without the use of spring compression. : : : :

Nature Supplies the Feeding Force in the Form of Compressed Air. : : : : : :

With many thousands of the "Philadelphia" Grease Cups in successful operation, on machinery of almost every description, we offer a system of lubrication which, for simplicity, cleanliness, economy, reliability and efficiency has no equal.

The "Philadelphia" Cup is not merely "as good as any other:" IT IS THE BEST, and we are prepared to prove our claim for actual superiority. There are more reasons for its practical success than we have room to mention here.

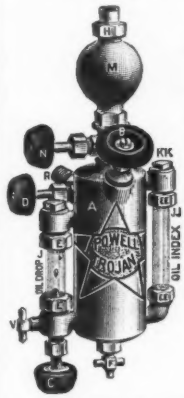
Write for catalogue and full information

The Philadelphia Lubricator & Manufacturing Co.
The Bourse (Exhibition Dept.), Philadelphia, Pa.

Two Powell Dependable Engineering Specialties

The **Powell Automatic Injector**

will lift water through 3 ft. of pipe between tank and combining tube on 18 lbs. steam pressure. Lifts water through 20 ft. of pipe at 60 lbs. pressure. The most reliable automatic injector on the market.



The **Powell TROJAN Sight Up-feed Lubricator**

This body shell is cast in one piece—Powell construction—arms can't get out of line, no joints to loosen or leak. This means positive feed and perfect lubrication. Absolutely reliable under all conditions. Oil chamber is filled directly through filling cup B on all sizes.

Powell's Steam Specialties are Standard. Ask your Jobber—he knows.

DID YOU GET OUR CATALOG?

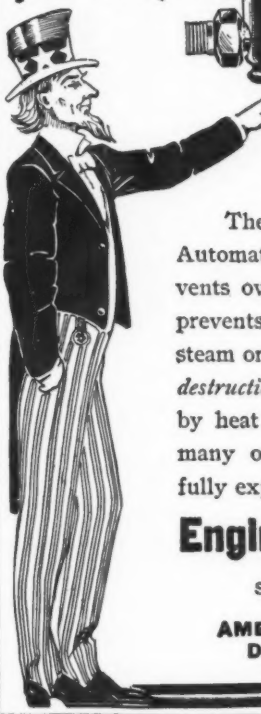
THE WM. POWELL CO.
Cincinnati, Ohio.

New York, 254 Canal St. | Boston, 239-45 Causeway St. | Philadelphia, 518 Arch St.

No Freezing Here

The Drip Cock prevents it

U.S. Automatic Injector



The Drip Cock of the U. S. Automatic prevents freezing; prevents overheating of suction pipe; prevents jet "liming up" when steam or check valve leaks; *prevents destruction of hose on traction engines* by heat from hot water, and has many other exclusive advantages fully explained in our

Engineer's Red Book

sent free on request.

AMERICAN INJECTOR CO.
Detroit, Mich., U. S. A.

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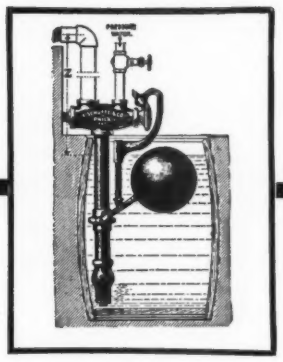

This appliance as illustrated is complete and automatic. It is operated by either steam or water pressure. When pit is filled it turns on pressure (water or steam) and remains turned on till pit is empty, when water shuts off till pit is full again.

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Cannot be beat for raising water from deep wells, mines or pits, filling or emptying tanks, raising or transferring liquids, etc.

Note the straight pipe connections making it desirable for elevating water from deep driven or drilled wells.

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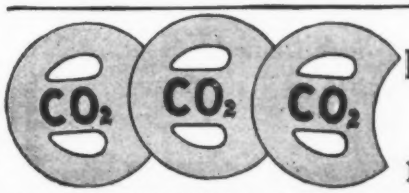

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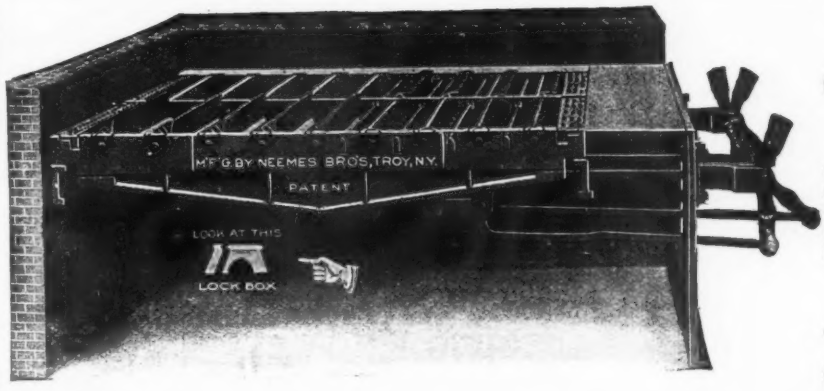

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IMPROVED
Clinker Cutting, Shaking and Dumping Grate
unlike all other grates will cut from both sides of the shaker alike. Makes more steam with cheaper fuel and less of it. A slight agitation shakes out the ashes or a full opening dumps everything into the ashpit. *Write.*

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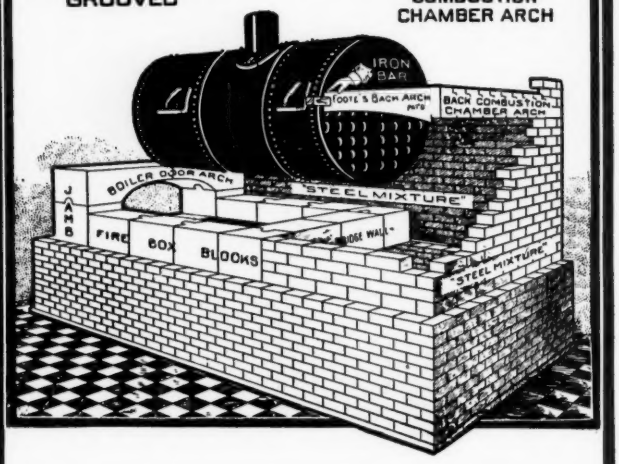

Dutch Ovens

Many users of Water Tubular Boilers have an inner arch or flame plate running back from the front. These are a more or less constant source of trouble.

We make a special radial block which we use in such cases as well as in ordinary Dutch Ovens. They are hard and durable and we can supply them for almost any width span. Feed hole blocks for sawdust burners can be furnished also.

These blocks have proved extremely efficient and we would be glad to make you a blue print and send you an estimate of cost for your particular case.

MANUFACTURED BY

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A DARK CLOUD

of smoke hanging over your plant is a positive indication that for every $100 worth of coal burned, from $5 to $15 worth goes up your chimney as waste fuel.

The Wilkinson Automatic Stoker and Smoke Preventer turns this dead loss into live profit. Let us tell you **how** in detail.

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HEAT PROOF

The heat resistance of our fire brick is wonderful. We fit every type of boiler setting.

Write for catalog and prices.

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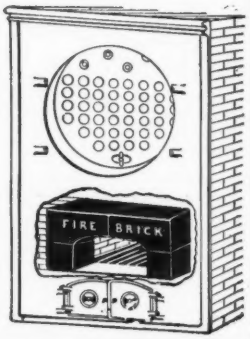

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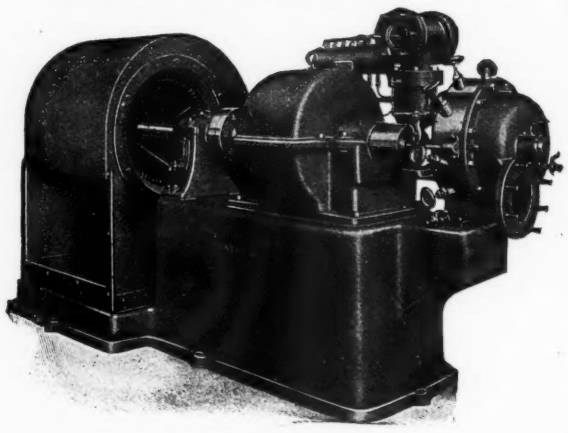
BLOWERS

BUILT ON THE TURBINE PRINCIPLE
MOST EFFICIENT FOR ALL DUTIES



STEAM TURBINE UNIT

20" Double Inlet Sirocco Blower, Direct connected to a steam turbine for forced draft. Capacity of 28,000 cu. ft. against a pressure of 5½" water Gauge. EFFICIENCY 65%.

SIROCCO ENGINEERING CO.

138-140 Cedar St., New York. **Works: Troy, N. Y.**

WE MAKE THE BEST CLEANERS
THE WORLD EVER SAW.

The "Torpedo" Fire Tube Cleaner.

The "TORPEDO" is the best fire tube cleaner because:

1st. It travels with triple the speed of any other cleaner (over 11,000 vibrations per minute). The more frequent the raps the lighter can they be, especially when nicely cushioned by both the piston and centering lugs as in the "TORPEDO."

2d. It is automatically centered in the tube. That is, there is no "wobbling" of the cleaner body in action. The stroke is then the same in every direction. Without centering, a cleaner can not use a definite regulated stroke. If the body is on the bottom of tube the stroke must be long enough to reach the top, but it is then TOO LONG on its lower stroke. In such a case it attempts to strike beyond and make a hole in the tube on all its downward strokes, and such a machine will likely stretch the tube.

3d. Simplicity means long life. The "TORPEDO" outside of the six lugs which have *only* to hold the cleaner centrally in the tube, has only one working part. This is the piston with its vibrator directly in its center. "TORPEDO" cleaners have cleaned over 50 boilers and showed little or no signs of wear. Read our folder No. 30, "How to Tell a Good Fire Tube Cleaner."

The "Demon" Straight Tube Cleaner.

The "DEMON" straight cleaner is unequalled for all straight tube boilers because:

1st. It is the only cleaner that uses water pressure directly upon rotary pistons, all others using the turbine principle.

This results in a far more powerful motor, and a greater torque amply sufficient to drive a non-centrifugal head. In other words the cutters are held out in a fixed non-yielding manner so as to attack the scale positively and crush it rapidly under the high twisting power of the "DEMON" motor.

2d. Because of the non-yielding character of the cutter head all scale must be removed down to the iron.

Patches of scale cannot be skipped over as with a turbine cleaner relying upon centrifugal action only.

3d. The "DEMON" can never injure a tube even when allowed to run indefinitely in one spot.

4th. Every machine is given a brake test and must operate at 300 lbs. pressure before leaving factory and it then goes forward with our guarantee to save 50% in time and 3% in fuel over any other cleaner in existence.

Send for folder No. 54.

The "Demon" Curved Tube Cleaner.

The "DEMON" curved tube cleaner solves the problem of rapidly and quickly cleaning all Stirling or other curved tube boilers better than anything else because:

1st. It has the same powerful piston type of motor as described under the head of the straight "DEMON."

This powerful motor means it can keep up a high speed of cutter head when working against the scale.

Careful tests show that the turbine cleaners maintain in the tube only 20% of their speed when running light outside of tube. The "DEMON" maintains 80%.

2d. The cutter head as a whole just fits a tube when clean. In the turbine all the cutter arms are thrown out by the weak centrifugal action only and can thus easily skip over scale. With the "DEMON" two of the cutter arms are non-yielding, the third yielding sufficiently to pass the bends and flats. This head removes the hardest scale down to the iron.

3d. The "DEMON" cleans the curved portion of the tube which so many cleaners only partially clean leaving the tube to burn out at the bend.

Send for folder No. 56.

Write for a cleaner on free trial.

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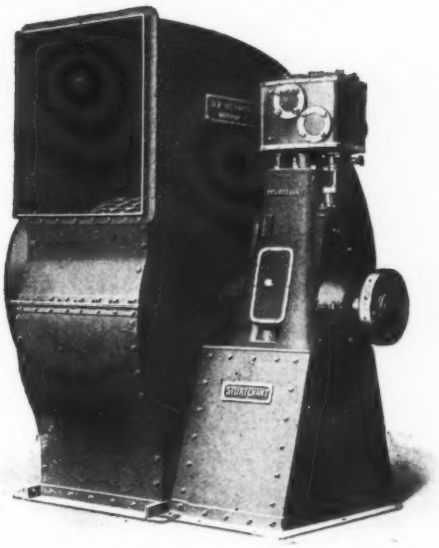
Includes the MOST EFFICIENT Commercial Fan in the WORLD.

Sturtevant Engines and Motors are Especially Designed for Driving Fans.



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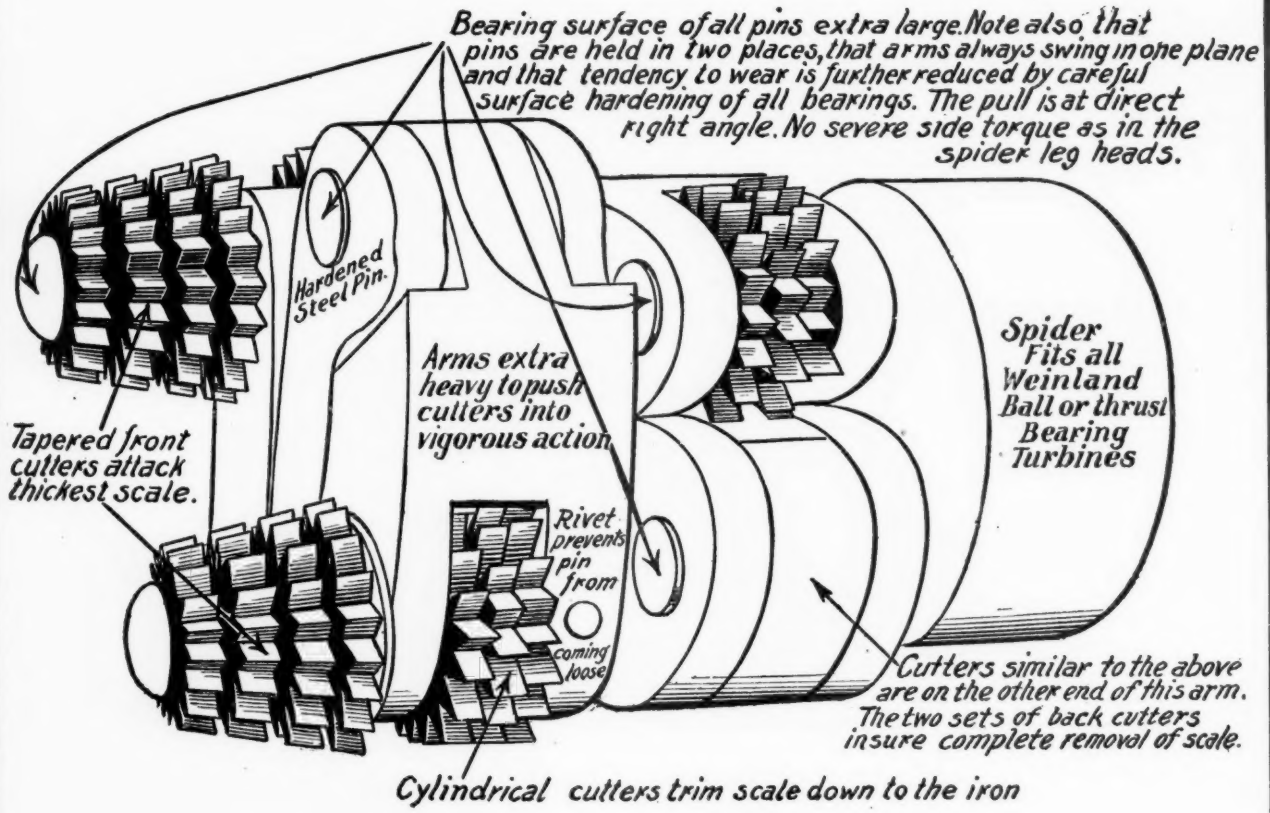
Designers and Builders of Heating, Ventilating, Drying and Mechanical Draft Apparatus; Fan Blowers and Exhausters, Rotary Blowers and Exhausters: Steam Engines, Electric Motors and Generating Sets; Pneumatic Separators, Fuel Economizers, Forges, Exhaust Heads, Steam Traps, Steam Turbines, etc. 695

This New Wing Head Is Now Furnished With All Weinland Turbine Cleaners And Can Be Applied To All Weinland Turbines Now In Use.


Bearing surface of all pins extra large. Note also that pins are held in two places, that arms always swing in one plane and that tendency to wear is further reduced by careful surface hardening of all bearings. The pull is at direct right angle. No severe side torque as in the spider leg heads.
Hardened Steel Pin.
Arms extra heavy to push cutters into vigorous action
Tapered front cutters attack thickest scale.
Spider Fits all Weinland Ball or thrust Bearing Turbines
Rivet prevents pin from coming loose
Cutters similar to the above are on the other end of this arm. The two sets of back cutters insure complete removal of scale.
Cylindrical cutters trim scale down to the iron

If your present turbine is not giving proper results, it will pay you to make this test. Try cleaning alternate tubes with our new WING HEAD CLEANER and any other make of cleaner. If the WEINLAND doesn't cut the scale out cleaner, do it quicker and with less water, you can send the Weinland Cleaner back without paying one cent. No other turbine has such a strong, effective head or will last as long in severe service. There is no wear out to those hardened steel arms and pins. Turbine wheel made with ball bearings for light duty and thrust bearings for heavy pressures. Which shall we send?

FOR EXTREMELY HEAVY SCALE ask about our Weinland Mechanical Cleaners driven by Electric Motor, steam or air pressure.

Write for catalog and treatise on "The Removal of Boiler Scale."

THE LAGONDA MFG. CO., Springfield, O.

Makers of the Lagonda Reseating Machine, the Lagonda Automatic Cut-Off Valve and the Lagonda Boiler Tube Cutter.

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Imitations do not have it—only the GENUINE.

SCRAPES AND BRUSHES IN ONE OPERATION

THE COMBINATION SCRAPER AND BRUSH
(Trade Mark Reg.)

The Protected spring acts on each arm equally and the cleaner is Self Adjusting. Ask your dealer for the GENUINE or send to

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MOREHEAD VACUUM TRAPS DRAIN LONG EXHAUST LINES AND VACUUM OIL SEPARATORS WITHOUT BREAKING THE VACUUM.
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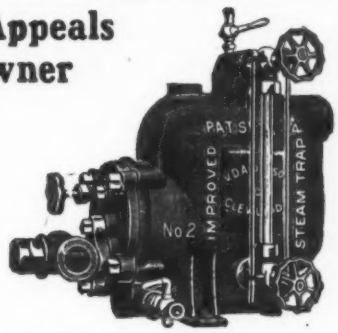
NOW IS THE TIME
TO INSTALL STEAM TRAPS

THE GEIPEL STEAM TRAP
is simple, efficient and economical, works equally well with high or low pressure steam and in any position.
WRITE FOR CIRCULARS
JOHN PLATT & CO., 97 Cedar St., NEW YORK

Fuel Saving Appeals To Every Owner

and labor saving appeals to every engineer. Both appeals are answered by the Anderson Improved Steam Trap.

Write for full particulars.



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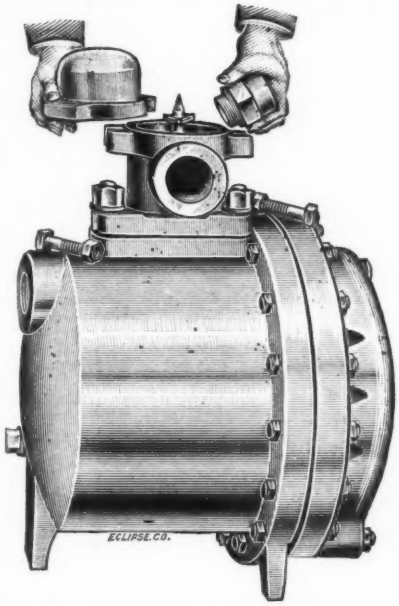
Steam Traps
4/S



As to Reliability and Satisfaction, we Guarantee that.

May we not send you our Catalog "A"?

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Steam Traps
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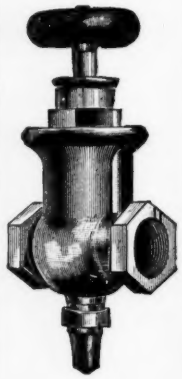

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It is your protection against poor goods and poor service—see that you get it.

Balanced Steam Trap
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These and other specialties described in our catalogue. Write for a copy.

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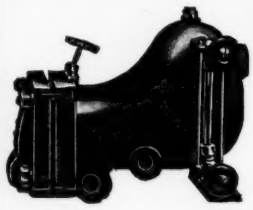

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are especially adapted for draining steam separators and high pressure mains. Also good for steam heating. All working parts are attached to the bonnet, and are removable with it. Valve outlets are large, to give rapid discharges of condensation.

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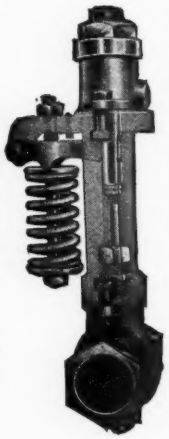


should be used on all steam pumps where a fixed discharge pressure is desired.

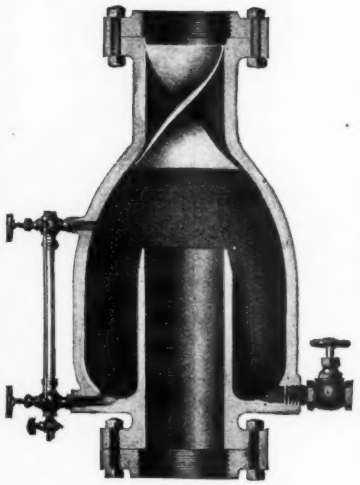
The construction permits of easy access to the stuffing box for removing packing, and the spring can be adjusted or entirely removed without interfering with any other part of the valve. Any practical man will readily see its advantages.

All our goods are made in our own factory and tested before shipping. We guarantee them to give perfect satisfaction. Established 1878.

Send for Catalogue.

Watson & McDaniel Co.,
148 North 7th Street, Philadelphia, Pa.

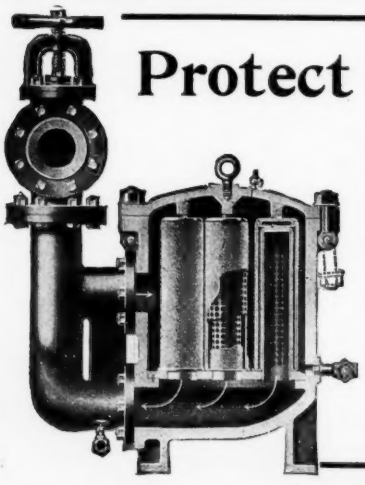
THE
"SWARTWOUT"
STEAM SEPARATOR



is so simple that anyone can understand its principle—the steam is given a whirling motion, throwing all water aside—the dry steam passes on. No baffle plates—direct steam flow. Efficient separation—no loss of pressure.

THE OHIO BLOWER CO.,
CLEVELAND, OHIO.

Also Manufacturers of "Swartwout" Gravity-Closing Ventilators. 1-59



Protect Your Boilers and Your Profits

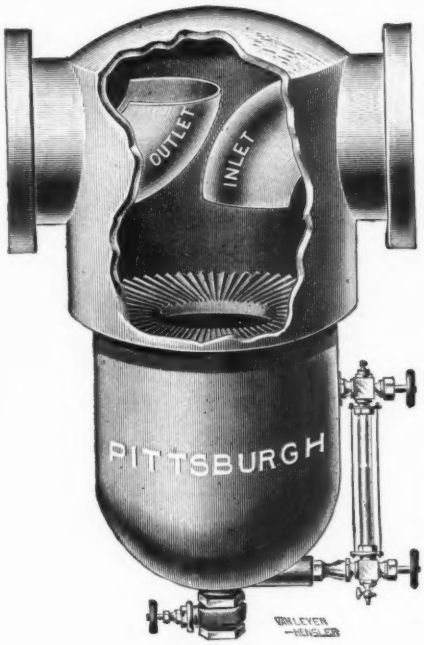
by keeping out oil and other floating feed water impurities. You can prevent the leaks, blistered tubes, bagged sheets and the waste of fuel caused by their impurities, by putting a

Blackburn-Smith Feed Water Filter and Grease Extractor

into the feed line. The filter will soon pay for itself in coal saved and reduced shut-downs and you won't need the boilermaker so often. Write for booklet "Feed Water Filtration."

106 Liberty St., **JAMES BEGGS & CO.,** NEW YORK.

"Pittsburgh" Steam Separators



Horizontal

For Live or Exhaust Steam

Utterly Simple **Perfectly Effective**

Highest Efficiency—
Proved by Laboratory Tests.

No Baffle Plates—
To Cause Spattering Back.

No Contracted Areas—
To Retard Freedom of Flow.

No Small Passages—
To Foul and Clog.

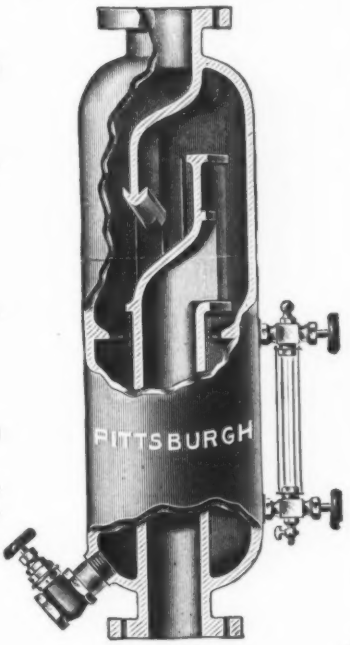
Perfect separation secured by sudden changes in direction of steam flow.

Separated water and oil drained directly away from steam current and into protected receiver space.

Horizontal and Vertical Types

Plain and Receiver Styles

Made in all sizes—Shipped on Guarantee Trial.

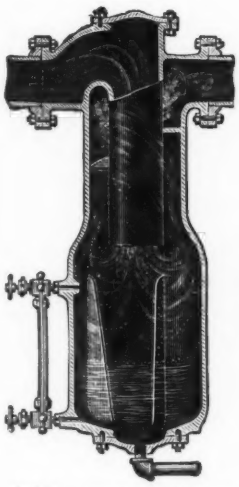


Vertical

Pittsburgh Gage & Supply Co., Pittsburgh, Pa.

Forcing The Boilers

Won't Increase the Power of Your Engine



if wet steam goes into the cylinder. It must reach the engine

ABSOLUTELY DRY

in order to make the forced firing profitable. And in order to get dry steam you must have a

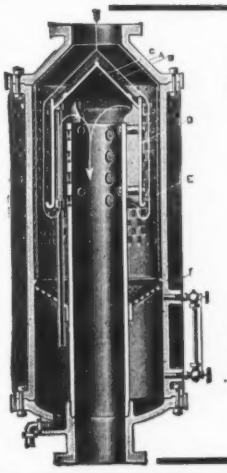
STRATTON SEPARATOR.

It is the only apparatus that is *absolutely infallible* under these conditions.

CATALOG WILL TELL WHY.

GOUBERT MANUFACTURING CO.,

No. 90 West Street. **New York City, N. Y.**



SWEETS

Steam Separators deliver 99.8 dry steam and oil separators remove 99% of oil from exhaust steam. They *do* it that's all. All styles.

DIRECT SEPARATOR COMPANY,

712 S. Geddes St., Syracuse, N. Y.

A MONEY BACK PROPOSITION

After a 30 days' trial—if you are not convinced that the Baum Separator will prove a profitable investment we will return your money and pay for returning the separator.

Send for new Catalog and prices.

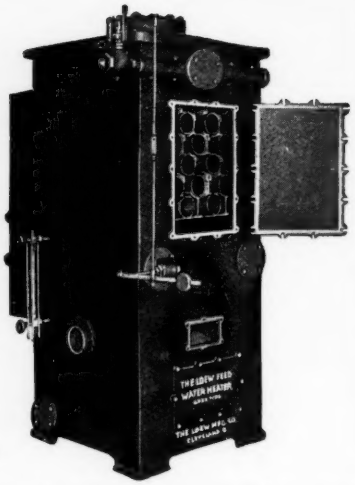
HERSHEY MACHINE & FOUNDRY CO.,

MANHEIM, PENNSYLVANIA, U. S. A.

W.G. Ruggles Co., 84 High St., Boston, Mass.
R. D. Bliss, 40 Dearborn St., Chicago, Ill.

The LOEW

Feed Water Heater



and Purifier does four things which make it invaluable to the wide-awake power user.

1—extracts the oil from the exhaust steam; 2—saves and utilizes the condensed exhaust steam; 3—removes scale-forming impurities and thoroughly purifies the feed water; 4—delivers the water to the boiler at a temperature of within 2 to 5 degrees of that of the exhaust steam. Write for complete catalog.

The Loew Manufacturing Co.
Cleveland, Ohio

Will Save Its Cost In

Boiler Repairs

and again in

Scale Elimination

again in

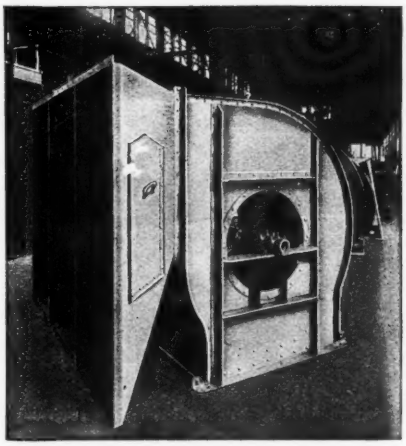
Fuel Costs

and again in

Reduced Leakage

Write for the Catalog.

THE STEWART HEATER CO.,
45 E. DELAVAN AVE., BUFFALO, N. Y.



Now is the time when all prudent men order Heating and Ventilating Equipment.

The designing and planning of a well considered heating and ventilating outfit take time, or, as the proverb says, "great affairs require long soaking." It is better to take the heating and ventilating of your plant or building up with us now than to wait until there is barely time to build and install the apparatus. Our engineering services and advice will cost you nothing, but may greatly reduce the cost and increase the efficiency of your installation, particularly as we build special fans and furnish special layouts wherever they are required.

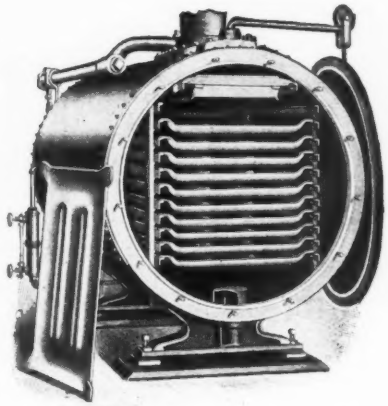
The above illustration shows a 70-inch wheel and Green Hot Blast Heater. As the heater is especially wide, three baffle-plates were inserted in the transforming area to distribute the air evenly. The Green Air Heater has certain special features which insure that it cannot become air-bound or short-circuited, that it will not be subject to water-hammer and that it can easily be inspected or cleaned.

Send for our new Booklet "109P" on "Heating and Ventilating Buildings."

The Green Fuel Economizer Co.
Matteawan, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers; Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines. 134



CLASS "F" CAST IRON CONSTRUCTION

HOPPES

Exhaust Steam Feed-Water Heaters and Purifiers

Are Built on Correct Principles

The raw water is brought in *direct contact* with the exhaust steam as it flows in *thin films* along the under sides of the pans, and as the pans afford a most extensive heating surface, it is heated to the *highest possible temperature* obtainable from exhaust steam.

The peculiar *trough shape* of the pans affords an excellent settling chamber for solids in suspension, while those thrown out of solution by the heat from the exhaust are caught and retained by capillary attraction on the under surface of the pans. The pans all rest on steel angle ways and are *easily removable* for cleaning.

Hoppes Heaters contain no perforated plates to give the "sprinkling can" effect and soon become clogged and inefficient, but the water flows smoothly and evenly over the heating surface and the heating and purifying action is in no way retarded by the deposit of scale on the pans.

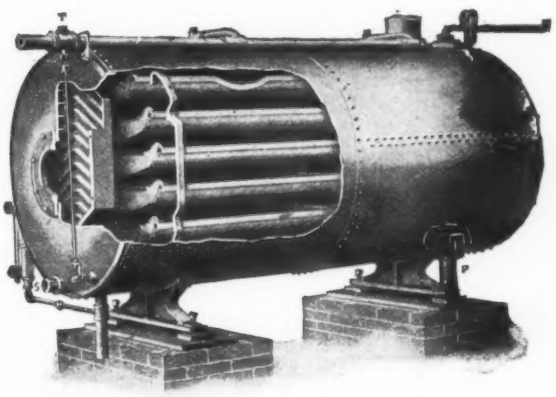
Every Hoppes Heater is provided with an efficient Oil Extractor and Automatic Feed-Water Regulating Valve and all fittings necessary to make it complete and ready for piping. They are built in either Steel or Cast Iron construction to suit conditions and requirements, and with or without water storage capacity as may be desired. GUARANTEED in every respect.

We also Manufacture

Live Steam Feed-Water Purifiers
Steam Separators Oil Eliminators
Cast Iron Exhaust Heads

WRITE FOR CATALOG

HOPPES MFG. CO.
19 Larch St., SPRINGFIELD, O.



STANDARD STEEL CONSTRUCTION

Harrisburg Feed Water Heaters

Of Pure Seamless Copper Coils. Guaranteed to be the most effective, most durable and cheapest heater manufactured.

Please write for Descriptive Catalog.

COPPER, IRON AND BRASS PIPE COILS AND BENDS OF ANY DESIRED SHAPE

Manufactured by

The Harrisburg Pipe & Pipe Bending Co.

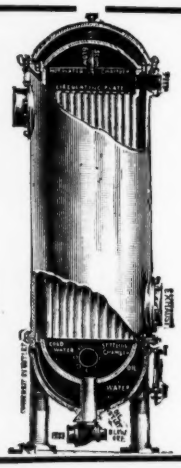
950 HERR STREET, HARRISBURG, PA.

Manufacturers of HIGH GRADE

Wrought Iron

PIPE

BLACK AND GALVANIZED



Perfect Circulation of Water and Steam

The steam area of the heater is about three times the area of the exhaust pipe, so that back pressure is impossible.

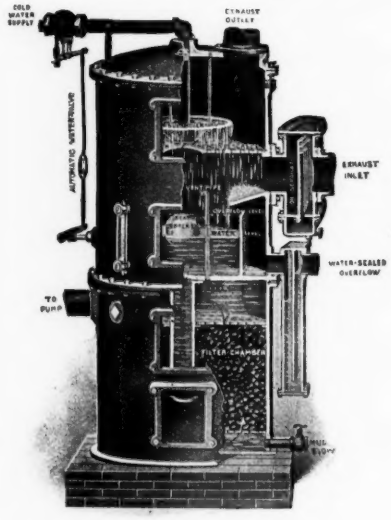
The combined area of all the tubes is four or five times the area of the feed pipe, but the water circulation is controlled by our circulating plate.

Ask For Our Illustrated Catalog

Erie Mfg. & Supply Co.

1203 Peach St., Erie, Pa.

THE WHITLOCK OPEN EXHAUST Feed Water Heater and Purifier



Perfect Oil Separation. Easily Cleaned. The Highest Possible Temperature in the Feed Water.

Manufactured by

THE WHITLOCK COIL PIPE COMPANY

HARTFORD, CONN.

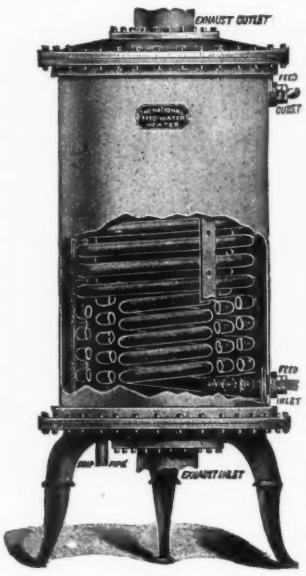
New York Office—Singer Building, 85 Liberty Street.

Your Exhaust is a Cost That's Lost

unless you put it to some practical use.

Doubtless you know that. Perhaps you haven't gotten at getting a feed water heater yet, or perhaps you have one, but aren't satisfied with it. At all events, consider the National Feed Water Heater; the simplest, safest and best heater made. Nearly 3,000,000 H.P. are in daily use, which proves that the "National" is not a "freak."

Write for a catalog.



The National Pipe Bending Co.

175 Lloyd Street, New Haven, Conn.

120 Liberty Street, New York. 54 High Street, Boston, Mass.

60 Days' Proof

We will send you, on trial, a

Patterson-Berryman Feed Water Heater

If it lives up to our guarantees, giving entire satisfaction in your plant, we will expect you to pay for it and you will be glad to do so. If it fails it will not cost you one cent. WRITE.

Frank L. Patterson & Co.
28 Cortlandt St., New York, U. S. A.

The Eclipse Feed-water Heater and Purifier prevents scale-forming impurities from entering the boiler.

Catalog?

The Eclipse Feed Water Heater & Purifier Company,
Oshkosh, Wisconsin.

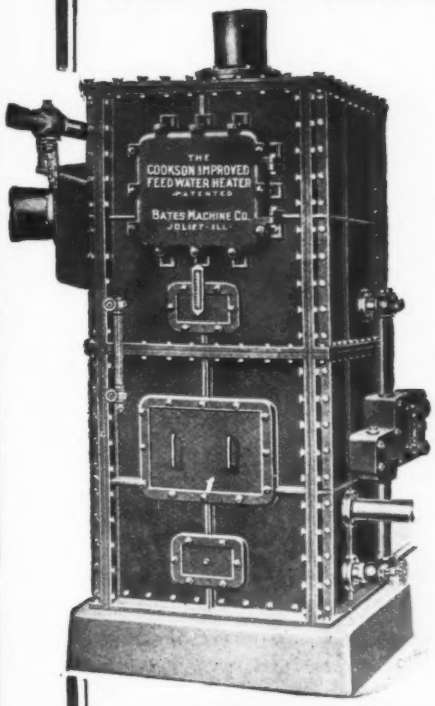
Dean Bros. Steam Pump Works

Simple Plunger Pump

INDIANAPOLIS

Simple and Duplex Boiler Feeders. Jet and Surface Condensers. Power and Electric Pumps.

COOKSON STANDARD ALL CAST IRON FEED WATER HEATERS



Highest Temperature and Positive Purification of feed water.

Perfect Separation and Removal of Oil.

Automatic Control of Cold Water Supply.

Dry Steam for Heating Purposes.

Finest Grade Special Fittings.

Lime Catching Pans. Especially Adapted for use with Heating Systems, Dryers, Etc.

Write for our new Heater Catalog.

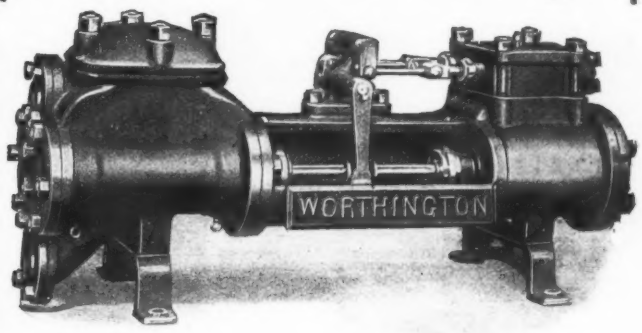
BATES MACHINE COMPANY
Sole Manufacturers Joliet, Illinois

Highest Heating Efficiency

The Reilly Multicoil Feed Water Heater guarantees the best results because of its superior method of bringing each particle of water in direct contact with the tube walls. It is free from scale and is so simple in construction that all internal parts can be reached through a large door in the shell without breaking a single external pipe connection. Catalog?

The Griscom-Spencer Co., 90 West St. New York.
STEAM BOILERS—ENGINEERS—TANKS

Boiler Feed Pumps



GRAVITY

separates the condensation from the exhaust as the steam revolves in the Gardner Exhaust Head, and gravity is a force that never fails.

WRITE.

The Gardner Governor and Separator Co.
Quincy, Illinois

If the Name of

WORTHINGTON

is on Your Pump it Means

BEST WORKMANSHIP
MATERIAL
DESIGN
SATISFACTION

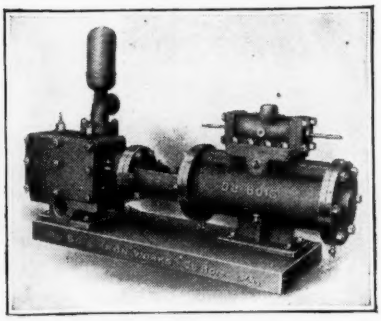
Write for Bulletin W. 117.

HENRY R. WORTHINGTON
115 Broadway, NEW YORK.
Works, Harrison, N. J.

DuBois Pumps

"STEAM TYPE"

All Working Parts Completely Covered



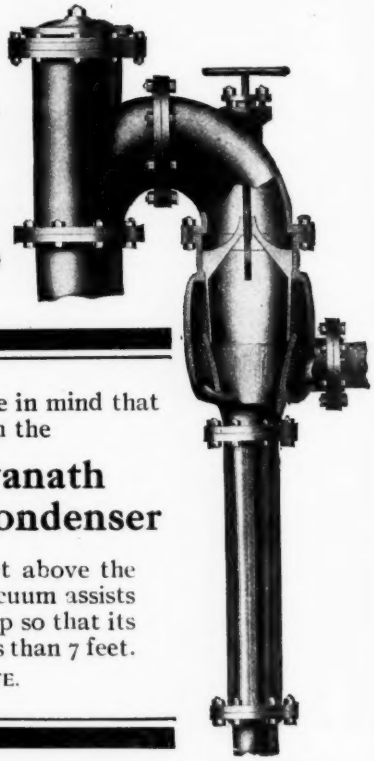
This feature, together with the single valve design of the Du Bois, results in the "unequalled simplicity" for which they are famous. Write for catalog E.

DU BOIS IRON WORKS

Established 1877

805 Brady Street **Dubois, Penna.**

Any Ordinary Pump Will Do



It should be borne in mind that although the

Baragwanath Syphon Condenser

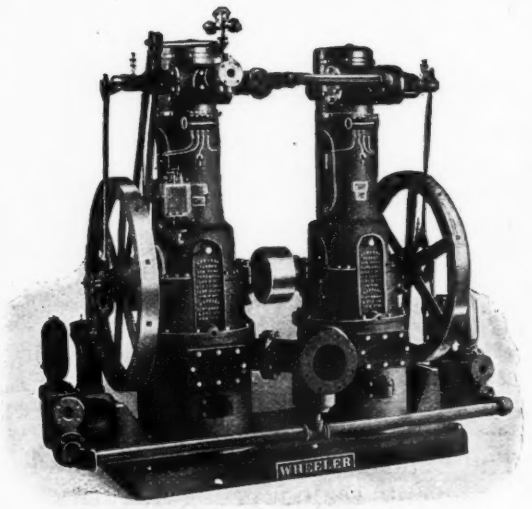
is placed 34 feet above the hot well, the vacuum assists the supply pump so that its actual lift is less than 7 feet.

WRITE.

WM. BARAGWANATH & SON,

54 W. Division St., Chicago, Ill.

Thos. B. Whitted, Piedmont Bldg., Charlotte, N. C., Southeastern Manager.



The Anti-Shut-Down Air Pump

If you have had dry vacuum pumps wrecked by water or have had to shut down, or to exhaust to atmosphere in order to repair pump valves on the ordinary types of air and condensation pumps, you will perhaps be interested in a pump that is specially proof against accidents of this kind.

We refer to the Wheeler-Edwards air pump shown above. It has only one-third as many valves as an ordinary air pump, since there are no foot valves nor bucket valves, the only valves used being head valves, and these are so located that they are easily inspected, repaired and replaced without taking the pump apart. This arrangement of valves has the further operating advantage of enabling the pump to give extra high vacuums, which is perhaps even more important than the practical advantages just mentioned.

In the pump shown above, there is a coupling between the two halves of the unit and either half can be run independently, giving a fair vacuum while the other half is being overhauled. It is unnecessary to duplicate apparatus or to carry spare parts.

This unit is provided with tail pumps which will lift the condensation 40 to 50 feet to elevated return tanks, or open heaters, often a great convenience where the condensers must be located below the turbine-room or engine-room floor. The air escapes through a vent to atmosphere and the valves of the pumps can easily be examined while the pump is in operation.

Write for special treatise "P" on Air Pumps.

WHEELER

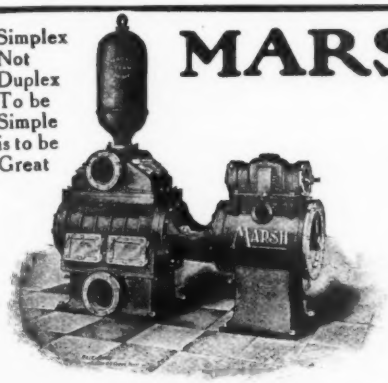
CONDENSER & ENGINEERING CO.

CARTERET, NEW JERSEY.

New York, Cincinnati, Chicago, Denver, Boston, Pittsburg, St. Louis, San Francisco, Atlanta, Houston, St. Paul.

(Builders of Wheeler Surface, Jet and Barometric Condensers, Wheeler-Volz Combined Surface Condensers and Feed Water Heater, Wheeler Feed Water Heaters, Barnard-Wheeler Cooling Towers, Wheeler-Edwards Air Pumps, Wheeler Centrifugal Pumps, Wheeler Rotative Dry Vacuum Pumps and Wheeler Multiple Effect and Evaporating Machinery).

Simplex Not Duplex To be Simple is to be Great



MARSH BOILER FEEDERS

are designed for handling hot as well as cold water. They are *at regular prices* fitted with bronze Piston Rods, bronze Water Cylinder Liners held in place by Studs, bronze Valve Seats, Stems, Nuts and glands. THE BEST OF MATERIAL AND THE BEST OF WORKMANSHIP ONLY GO INTO **MARSH PUMPS.**

Write for Catalog 17-G.

American Steam Pump Co., Battle Creek, Mich.

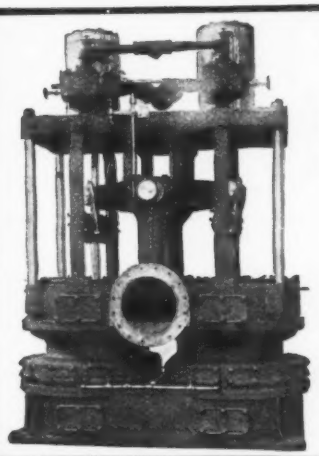
HEINE WATER TUBE BOILERS

AND SUPERHEATERS

All Flange Steel Construction

Send for { Boiler Logic and Superheater Logic

Heine Safety Boiler Co. 421 Olive St., St. Louis, Mo.



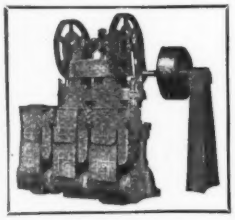
WARREN STEAM PUMP CO.
Warren, Mass.

PUMPS FOR ALL REQUIREMENTS

PISTON—PLUNGER
HYDRAULIC DEEP WELL
POWER.
Air Pumps and Jet Condensers Combined.
Air, Circulating and Marine.
Duplex Vertical Air Pump and Jet Condenser.
CATALOGUE.

Deming

Ask for Catalogue "G" and treatise "Feeding Boilers."



For any service. **Power**

For operation by any power. **Pumps**

The Deming Company
Agencies in Principal Cities
Salem, Ohio

Alberger Condenser Co.

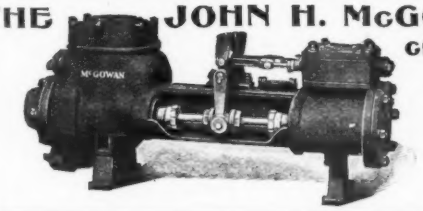
Condensers, Cooling Towers, Vacuum Pumps, Heaters

95 Liberty St. New York

Centrifugal, Volute, and Turbine Pumps

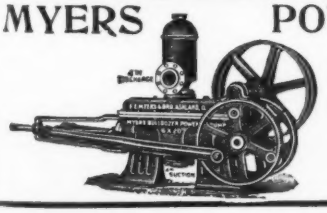
Alberger Pump Co.

THE JOHN H. McGOWAN CO.
Cincinnati, Ohio



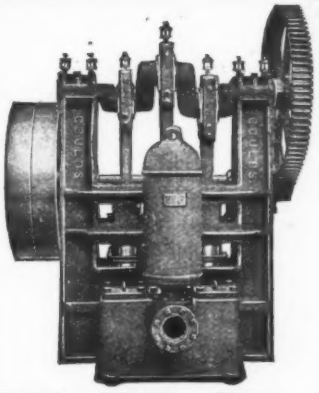
Builders of
PUMPING MACHINERY
Single Duplex and Fly-Wheel Types
Water Works Pumping Engines

MYERS POWER PUMPS



Adapted especially for gas engines, motor and belt powers, in harmony with present requirements.
Catalog sent on request.

F. E. Myers & Bro.,
Ashland, Ohio, U. S. A.



GOULDS

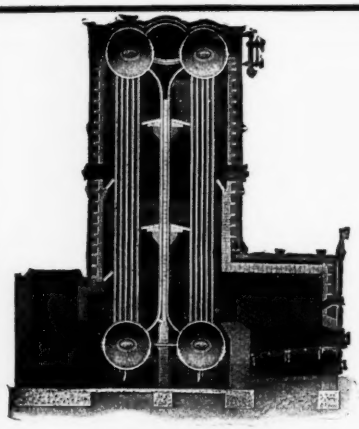
EFFICIENT POWER PUMPS

Built in the best manner and of material that can be depended upon. They will be found to fully sustain the high reputation of

GOULDS QUALITY

THE GOULDS MFG. CO.,
Seneca Falls, N. Y.

New York. Philadelphia. Pittsburg. St. Louis. New Orleans. Chicago. Los Angeles. San Francisco. Louisville.



TYPE B

THE RUST
WATER TUBE
BOILER

SAFE, SIMPLE, DURABLE,
ECONOMICAL, ACCESSIBLE

Write for Report of Tests by William Kent.

THE RUST BOILER CO.,
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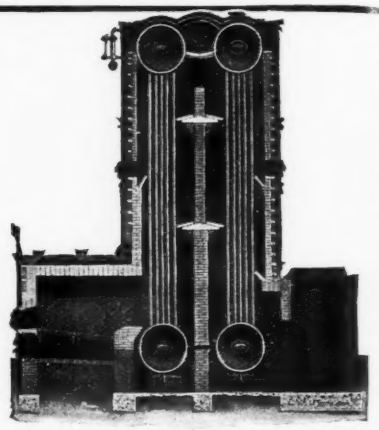
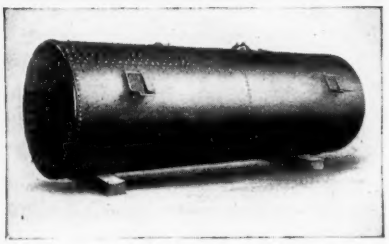
Branch Offices: New York, 50 Church Street; Birmingham, Alabama, First National Bank Building.



TYPE O

PARKER BOILER CO.
WATER TUBE BOILERS—SUPERHEATERS.
PHILADELPHIA, PENNA.
New York—Pittsburg—Chicago—Denver—San Francisco.

Foster Superheaters
Greatly increase capacity and permanent efficiency of steam turbines.
POWER SPECIALTY CO.,
111 BROADWAY, NEW YORK.



WICKES Horizontal Tubular Steam Boilers
HIGHEST GRADE
THE WICKES BOILER CO.
Also Manufacturers of the Wickes Vertical Water Tube Safety Steam Boilers
Main Office and Works, Saginaw, Mich.
SALES OFFICES:
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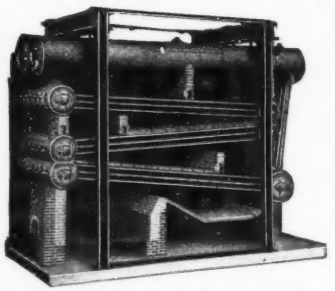
1139 American Trust Bldg., Chicago, Ill.
Penobscot Bldg., Detroit, Mich. Empire Bldg., Pittsburg, Pa.
601 Brown-Marx Bldg., Birmingham, Ala.

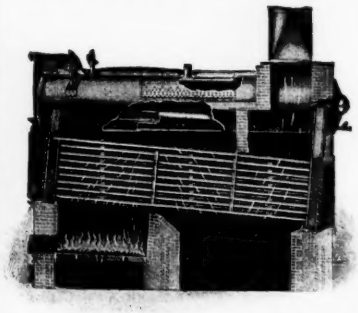
QUICK TO REPAIR

because all tubes are straight commercial sizes. Not one pound of cast iron is used in the construction of the Vogt Water Tube Boiler—steel only is used throughout. Large heating surface—rapid circulation—greatest flexibility. WRITE!



HENRY VOGT MACHINE CO., INC.,
LOUISVILLE, KY.

Water Tube Boilers



All Wrought Steel Construction

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ESTABLISHED 1865.

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Williamsport, Pa.

New York, Philadelphia, Chicago, San Francisco, Wilkesbarre and New Orleans.

KEWANEE TANKS

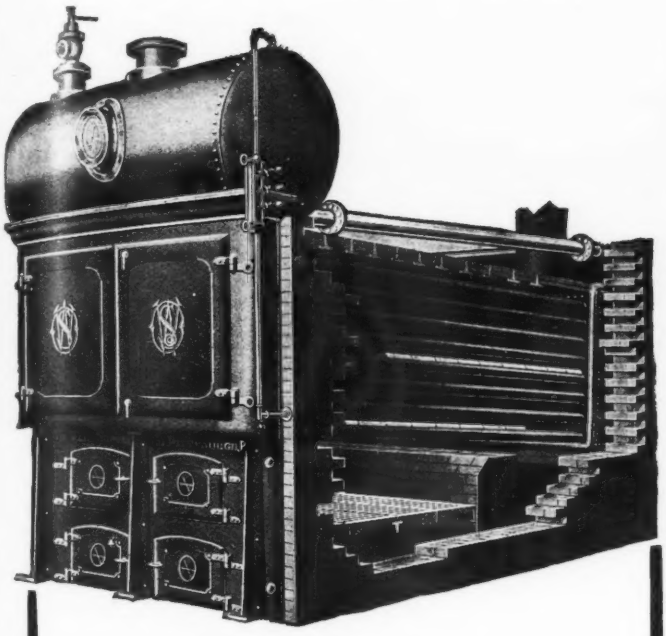
We are the largest and best manufacturers of storage and pressure tanks in the United States. The story is told. See Book No. 51. Send your specifications.

KEWANEE BOILER COMPANY
KEWANEE, ILLINOIS.

Edge Moor Boilers
—WATER TUBE—
EDGE MOOR IRON CO., Edge Moor, Delaware

Special setting features to meet all conditions.

Send for Catalog S.



The Basis Of Economy

in any power plant is the boiler system. If you appreciate that fact you will do well to investigate

Our Safety Water Tube Boiler

Built for any pressure from 125 to 300 pounds. Meets all the high duty requirements of modern triple and quadruple expansion and compound engines. Perfect circulation, remarkable economy, and freedom to expand and contract, are features.

Ask for illustrated catalog and latest test report.

Oil Well Supply Co.,
Pittsburgh, Pa.

Boiler Works Dep't., - - OSWEGO, N. Y.

Branch Offices—NEW YORK, PHILADELPHIA.

Uncle Sam thought the

Copes Boiler Feed Water Regulator

looked good

enough to regulate the feed water for his new B. & W. Boilers in the Charlestown Navy Yard.

As a rule, Uncle Sam is not "the first by whom the new is tried," but we were able to refer him to plants where Copes Regulators have been in successful operation for ten years, saving money by increasing the efficiency of the feed water heaters and economizers; besides protecting the boilers from low water, the engines from high water and the super-heaters from scale and making the work of the pumps easier and more regular.

If you have never looked into this feed water regulator question thoroughly, write for a copy of our New Book "P."

The American Boiler Economy Co.

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BOSTON Oliver Bldg. | NEW YORK Tribune Bldg. | BALTIMORE 226 E. Pleasant St.

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

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HAVANA, CUBA—116½ Calle de la Habana
LOS ANGELES—Trust Building
CINCINNATI—Traction Building
SEATTLE—Mutual Life Building

As Standard In The Mechanical World

as is the gold dollar in the world of finance.

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The Fisher Governor Co.
Marshalltown, Iowa.

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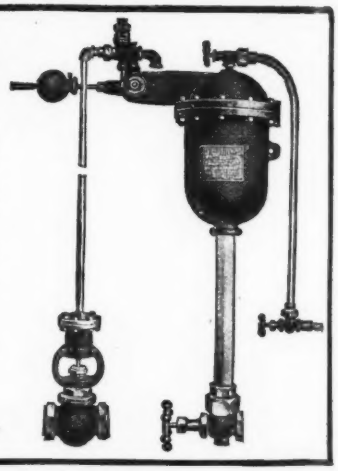
for Steam Boilers was the first in the field, and has the longest and best record of any of these devices. *Costs less to operate and maintain.* Constructed on a different and better principle than any other. Investigate it and the FULTON PUMP GOVERNOR, and send for latest catalog with list of users. A guarantee from a responsible firm with every machine.



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The overload capacity of **C-W** electric generators makes them popular with the engineer. In emergencies they do better than is expected of them. Bulletin 80M describes our D. C. machines.

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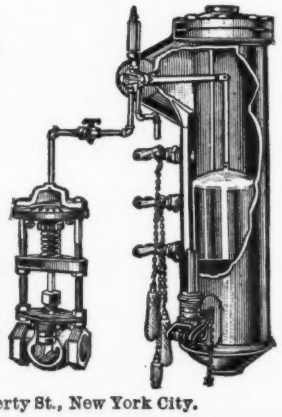

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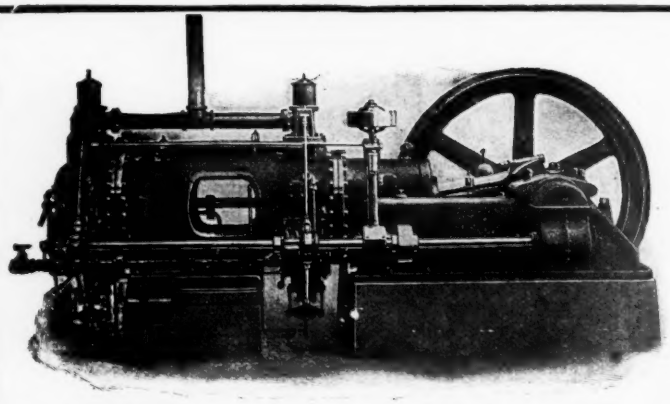
Chester, Penn.
Metropolitan Office, 136 Liberty St., New York City.



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Economy and Reliability Have Been Demonstrated by Actual Service

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You should always know the heat value of the gas you use.
The Sargent Gas Calorimeter is as essential to the Gas Engineer as the indicator is to the Steam Engineer.
It is accurate, is the very best of construction, and saves the operator 50% of his time.

Write for Catalog and "Testing of Inflammable Gases" Booklet

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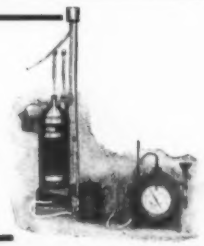

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They hold their pressure under unfavorable conditions and are free from weaknesses of all kinds.
Produce more steam per pound of coal than any other make. Booklet on request.

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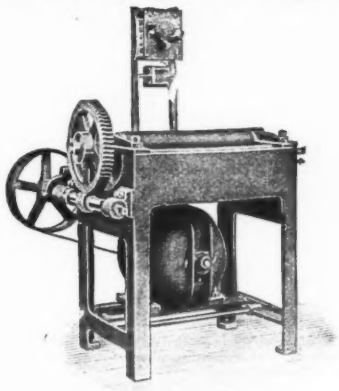
Let us send you our booklet "The Way to Forget"



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Save 50 to 75% in fuel costs. As compared with steam.

Foos Engines, owing to their efficiency and reliability, are the ideal power for factories, water works, electric plants, etc. They pay for themselves in one to three years.

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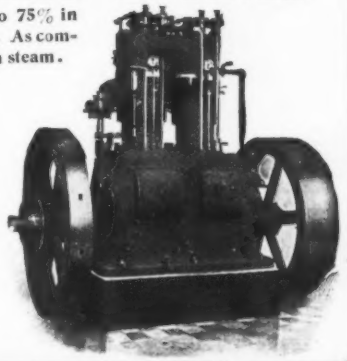

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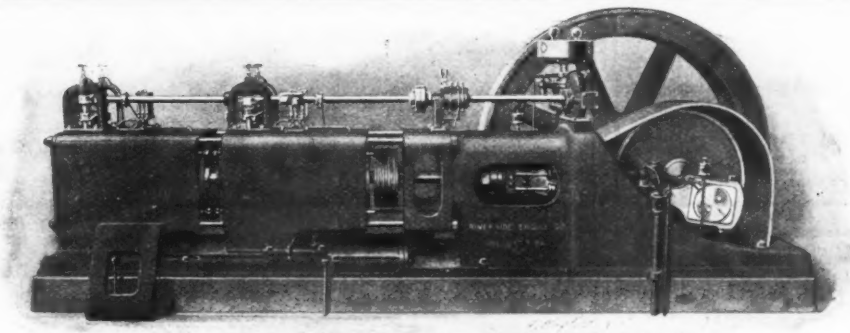

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We Guarantee

We guarantee this engine to be strictly first-class and we will replace any part or parts that may prove defective within one year. We further guarantee that it will develop the rated H.P., carry momentary overloads of 20% and require the services of but one man to start and operate.

We also Build a Complete Line of Gas Driven Air and Gas Compressors.

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Porter-Allen Automatic Steam Engine,

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The design is unsurpassed for simplicity and compactness, while the details of valves and gear, bed-plate construction, etc., are greatly liked by all users.

Adapted to every class of service.

MANGANESITE PASTE

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A Superior NON-POISONOUS Jointing Material of Metallic Composition; for FLANGE and SCREW-JOINTS of every description on Steam, Water, Air, Gas, Ammonia, etc. UNITES TWO METALS AS ONE. Cheaper, more efficient than red lead—no waste in its use.

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that works quick and easy and keeps its lustre. Holds old trade and makes new. IT DOES NOT DETERIORATE. Established 16 years.

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NORTHERN TRANSMISSION SYSTEMS FIT OLD PLANTS AS WELL AS NEW

The use of our product assures convenient, speedy, economical production. Our generators are readily installed in connection with old power plants. Our motors are easily applied to all classes of machine drives. If you want us to discuss your requirements for electrical machinery, say what you plan doing electrically. Tell us at once so that our propositions and suitable literature may be in your hands for early consideration. Send for bulletin 850.

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Always just a shade better than the best of their competitors. The superiority is unusually marked in our **Small Vertical Engines,** 8 to 75 H. P.

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We Manufacture

AN ECONOMICAL AND DURABLE ROTARY ENGINE

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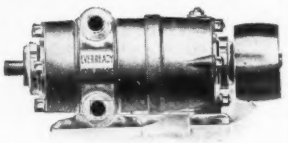

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This cut represents our new set of 20 tools gotten up for use in the engine room. Strictly high-grade tools with all the good points of toolsmithing in their make-up. Conveniently arranged in finished Oak Case and every tool is guaranteed.

No. 20 Set of 20 Tools . . . $4.00.

Book "Engineers' Chums" free. Address Dept. B

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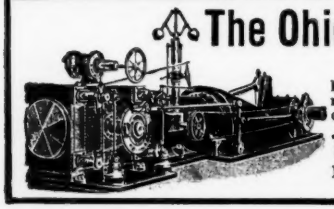
The Ohio Corliss Engine



For hard work, heavy loads and high-speed, the Ohio shows close regulation and runs smoothly and quietly.

THE GRIFFITH & WEDGE CO.

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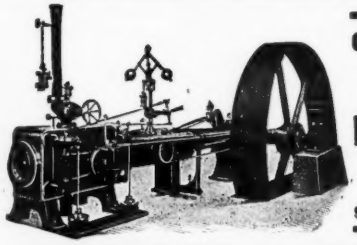

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Refrigerating and Ice Making Machinery

THE VILTER MFG. CO.

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CORLISS ENGINES

For Reliability and Economy.

Built by

PROVIDENCE ENGINEERING WORKS,

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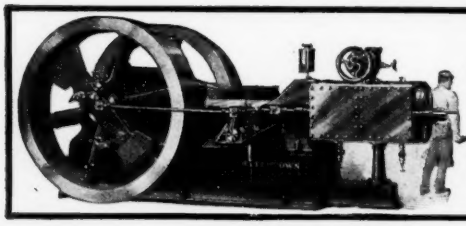

Good Engines

for every power purpose. Ask for Catalog.

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ALBERGER TANDEM GAS ENGINES

ACCURATE REGULATION FOR ELECTRIC SERVICE—AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR

A.H.ALBERGER COMPANY

45 TO 600 H.P. USING NATURAL GAS
35 TO 500 H.P. USING PRODUCER GAS

695-697 ELLICOTT SQ.
BUFFALO, N.Y.

YOURS

ON A MINUTE'S NOTICE

We have for immediate delivery:

One 18-inch by 42-inch girder frame engine, left hand, 90 revolutions, rated at 250 h.p.; wheel 14-ft. diameter by 48-inch face.

One 19-inch by 42-inch girder frame engine, right hand, 100 revolutions, rated at 280 h.p.; wheel 14-ft. diameter by 33-inch face.

The above are **new** engines.

One 14-ft. diameter by 28-inch face pulley, turned for belt. Hub bored 11-inches diameter. Wheel weighs 15,000 pounds.

Get busy and communicate with us.

C. H. BROWN ENGINE CO., Inc.

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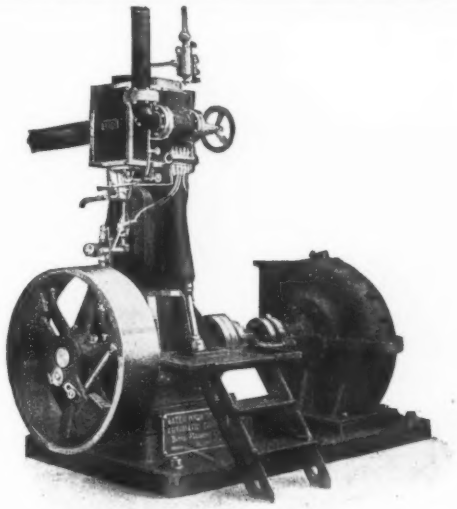
Chicago Representative—FRANK H. POND & CO., Fisher Bldg.



Bates Vertical Automatic High Speed Engine for connection to Pumps. Especially adapted for

WATER WORKS, IRRIGATION

and other places where it is desired to move a large volume of water at small expense.

CATALOG FOR THE ASKING.

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ENGINES

20 x 42 Allis, Corliss	16 x 32 Buckeye, Automatic
18 x 42 Hamilton Corliss	14 x 24 Atlas, Automatic
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Also large assortment of Automatic and Throttling Engines of other sizes.

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84 x 18, 78 x 16, 72 x 18 High Pressure, 72 x 16, 66 x 16 and smaller sizes of Horizontal Tubular Boilers, also Vertical and Fire Box Boilers from 5 to 60 H. P.

Heaters, Pumps, Tanks, Saw Mills, Iron Working Tools, etc., etc.

Write for bargain list.

We are the sole manufacturers of the celebrated "Leader" Injectors and Jet Pumps.

THE RANDLE MACHINERY CO.

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A Different And Better Bearing Metal

The Stage Coach used to be the thing—until the Locomotive came along. So did ordinary babbit—until "The Reeves" Bearing Metal showed engineers the way to get better results on all factory and machinery bearings. It's worth every cent of its price; 25 cents a pound. If your dealer hasn't got it, write to us for a 50 lb. trial box. Test is the best proof.

Reeves Pulley Company

Columbus, Indiana

"True in the long run."

Making ends meet is sometimes a difficult task. The constant, little expenses keep many a man from taking a summer vacation.

With the Triumph Ice Machine there are no constant, little expenses. That means saving; in the long run the profits accumulate.

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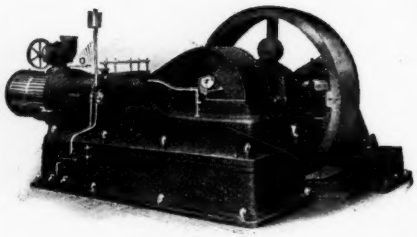

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Skinner Engines

CENTER CRANK
SIDE CRANK
SINGLE and FOUR VALVE

Skinner Engine Co.,
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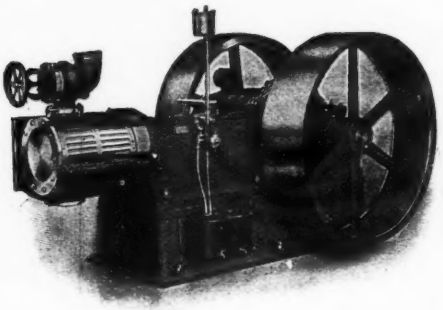

CENTER CRANK TYPE

BUCKEYE ENGINE COMPANY,
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BUILDERS OF HIGH CLASS

STEAM AND GAS ENGINES

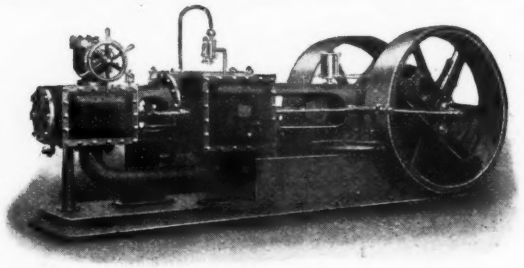
HIGH IN DUTY, SUPERIOR IN REGULATION
AND
ABSOLUTELY RELIABLE
CORRESPOND WITH US BEFORE PURCHASING
CATALOGS ON APPLICATION

They Require Little Attention And Less Repair

Operating under the most severe conditions where rapid fluctuations of load are encountered

The McEwen Engines

are guaranteed to show the closest regulation, the highest efficiency and economy attainable under present conditions. *Bulletin?*



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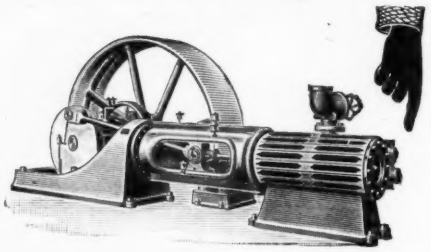
Twenty Hours In Twenty Years Is Enough

to keep the Fitchburg just as steam tight as the day it starts work in your plant.



Other of its advantages are positive adjustments to compensate for wear and perfectly balanced piston valves. Write.

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Geo. H. Conner, 509 Mutual Life Building Philadelphia. Western Trading Co., San Francisco. W. C. Teas, Chattanooga, Tennessee.

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CHESTER, PENNSYLVANIA.

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Manufacturers

POWER PLANTS BOILERS

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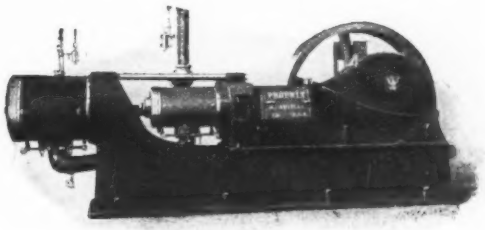
BUILDERS OF

AUTOMATIC CUT-OFF ENGINES

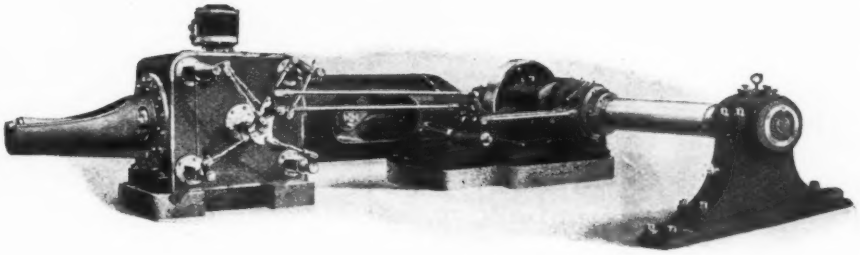
ALSO

BOILERS, HEATERS, TANKS AND GAS CONDENSERS



General Offices and Works: - - MEADVILLE, PA.

THE CLARK HEAVY DUTY CORLISS ENGINE

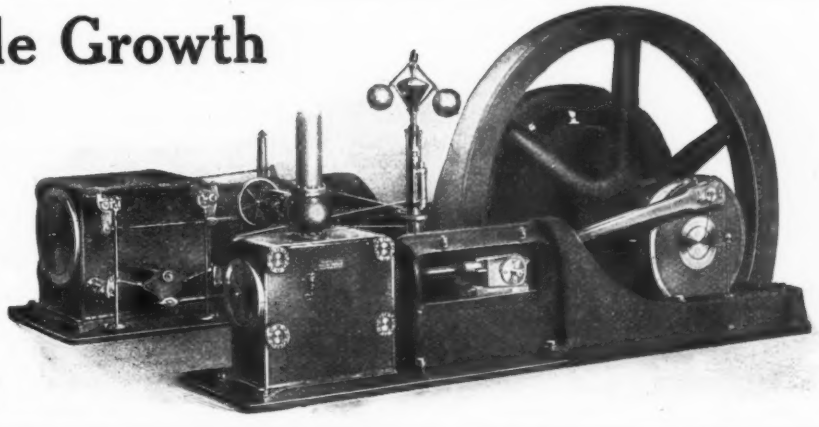


Valve travel never varies. No other Corliss engine has this advantage. Result perfect valve seats. Cuts off at all loads. As quick as the releasing gear. Heavy duty bed with bored guide. Main bearings half diameter of pistons. Length in proportion. Outboard bearing pedestal type. Adjustable in all directions. And self-oiling. Shaft swelled between bearings. Wheels above ten feet in diameter in halves. All wheels have split hubs. Our engines are unequaled for low steam consumption, perfect regulation, long life, nominal repairs, beauty of design. Perfect distribution of metal, high class material. Perfect workmanship.

THE CLARK BROS. CO., - Belmont, N. Y.

The Remarkable Growth

in the demand for Cooper Corliss Engines has, within the last few years, compelled us to more than double our manufacturing facilities. Ask for particulars.



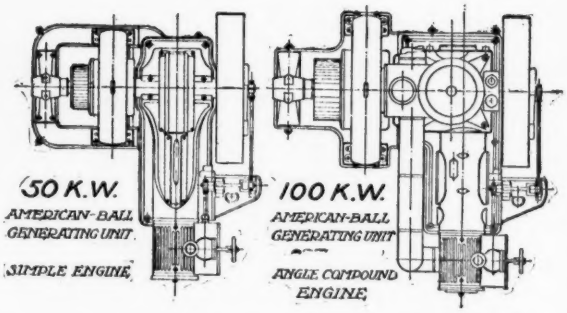
THE C. & G. COOPER CO.
Mt. Vernon, Ohio.

BRANCH OFFICES:

New York, 918 Bowling Green Bldg.; Boston, 411 Weld Bldg.; Pittsburg, 604 Frick Bldg.; Philadelphia, Drexel Bldg.; Atlanta, 310 Candler Bldg.; Charlotte, N. C., Court House Square; Chicago, 1539 First Nat'l Bank Building.

Is Your Floor Space Valuable ?

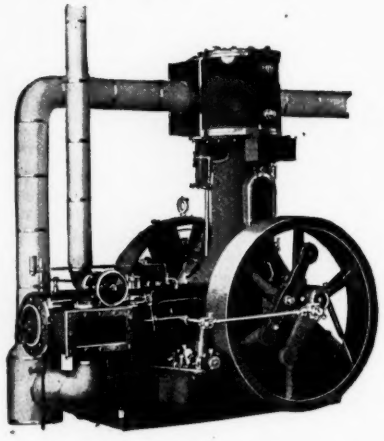
The Floor Space of an American-Ball Angle Compound Engine is practically identical with that occupied by a simple engine of half the H. P.



If floor space is a valuable and important consideration in your plant, you cannot fail to be impressed with the above diagrams comparing the floor space of Simple engine and Angle Compound engine generating units. Both are drawn to the same scale. Note that the outfit on the right, driven by the

American-Ball Angle Compound Engine

occupies almost exactly the same floor space as the other, but GIVES TWICE THE POWER.



This American-Ball Angle Compound Engine takes less room than a tandem or a cross-compound. We would also like to show you how the American-Ball Angle Compound excels in design and workmanship, how it excels in steam economy, close regulation and in balancing.

If you are interested in high-class steam engines write for Bulletin No. 14.

AMERICAN ENGINE CO.,
22 Raritan Ave. BOUND BROOK, N. J.

8

Small Curtis Turbine Generators

For Direct Current 20, 25 and 35 kilowatts

These sets consist of a Curtis Steam Turbine, direct connected on the same shaft to a shunt or compound wound General Electric Generator. The turbine is the single stage, non-condensing type with three sets of bucket wheels, mounted on the same hub. Between the wheels are the intermediate or stationary buckets. The nozzles are contained in a separate casting. Steam is admitted through a strainer to the steam chest and is passed through balanced valves operated by the governor, directly to the steam nozzles, thence through the turbine and to the exhaust.

Turbine end view of 20 kw. Curtis Turbine Generator., Speed 4500 r. p. m. 125 volts. Length 5½ ft. Weight 1850 lbs.

These sizes may be arranged to operate at any steam pressures above 80 lbs., and no difficulty is encountered in using steam superheated to 200 degrees F. As no internal lubrication is required in the turbine the exhaust steam is absolutely clean and can be turned into a heating system without risk of clogging the system with oil.

General Electric Company

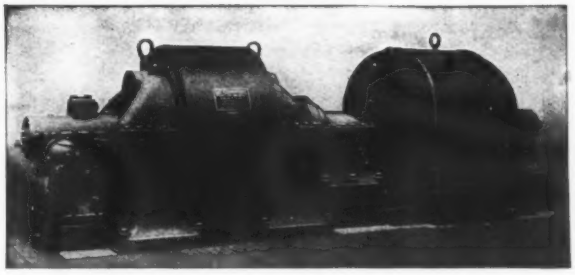
Principal Office: Schenectady, N. Y.
New York Office: 30 Church Street.
Sales Offices in all large cities.

1791

Westinghouse

Exhaust Steam Turbines

effect twice as great a steam economy, when compounded with a good non-condensing engine, as the engine will develop condensing.



Westinghouse Exhaust-Steam Turbine Generating Unit

The generally accepted maximum gain in steam economy secured by running a compound engine condensing is 25 per cent. With a simple engine it is not more than 17 per cent. A Westinghouse Exhaust Steam Turbine effects a gain of 50 per cent. and more in steam economy, and doubles the power producing capacity of the boiler equipment.

Ask our nearest office to prove these statements.

The Westinghouse Machine Company,

Steam Turbines, New York, 165 Broadway. Boston, 131 State Street. Cleveland, New England Building.

Steam Engines, Atlanta, Candler Building. Chicago, 171 La Salle Street. Cincinnati, Traction Building.

Gas Engines, **Gas Producers,** St. Louis, Chemical Building. Pittsburg, Westinghouse Building. Philadelphia, North American Bldg.

Storage Batteries and the Roney Stoker Denver, McPhee Building. San Francisco, Hunt, Mirk & Co.

York Manufacturing Co.

York, Pennsylvania

We manufacture all machinery and parts needed to equip a complete Ice or Refrigerating plant—

Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings.

of all kinds. We employ over 1,250 men in the manufacture of Ice and Refrigerating Machinery exclusively. Catalogue sent upon request.

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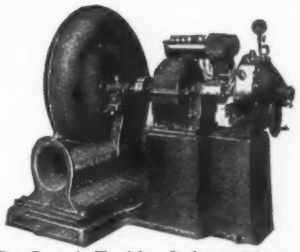
DE LAVAL



De Laval Turbine-Driven Blower.

Steam Turbine Motors
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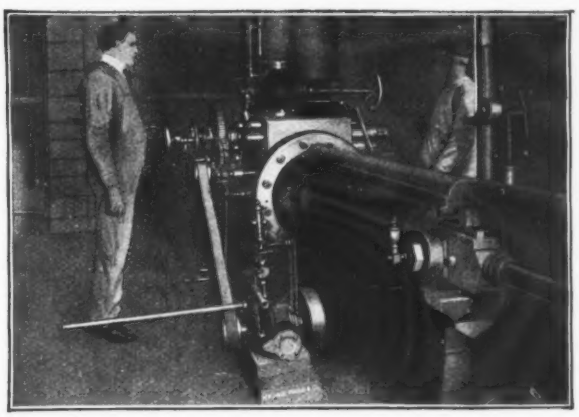
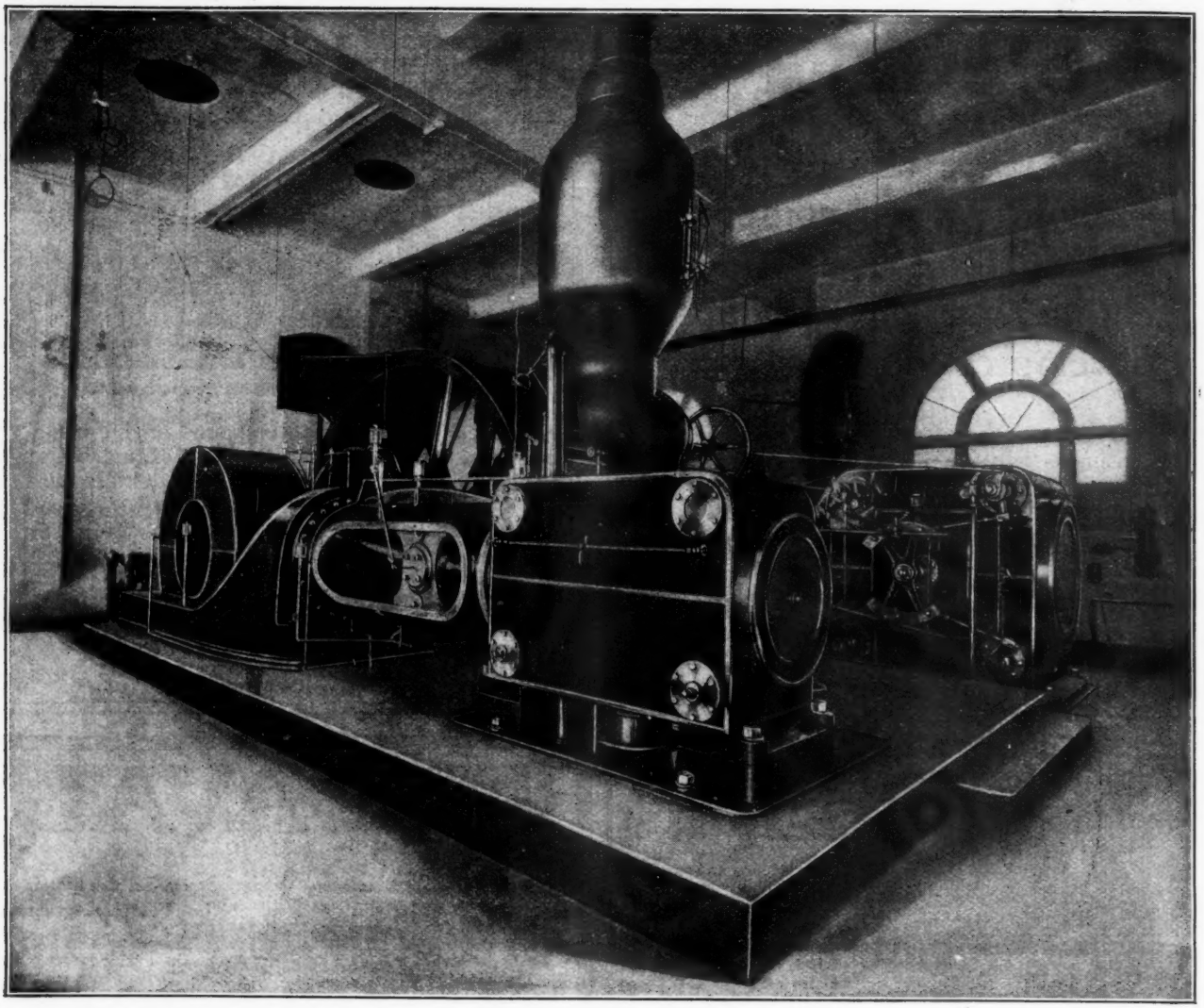


Twin City CORLISS ENGINE



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